NASA

Aeronautical Engineering
A Continuing Bibliography with Indexes

NASA SP-7037 (255)
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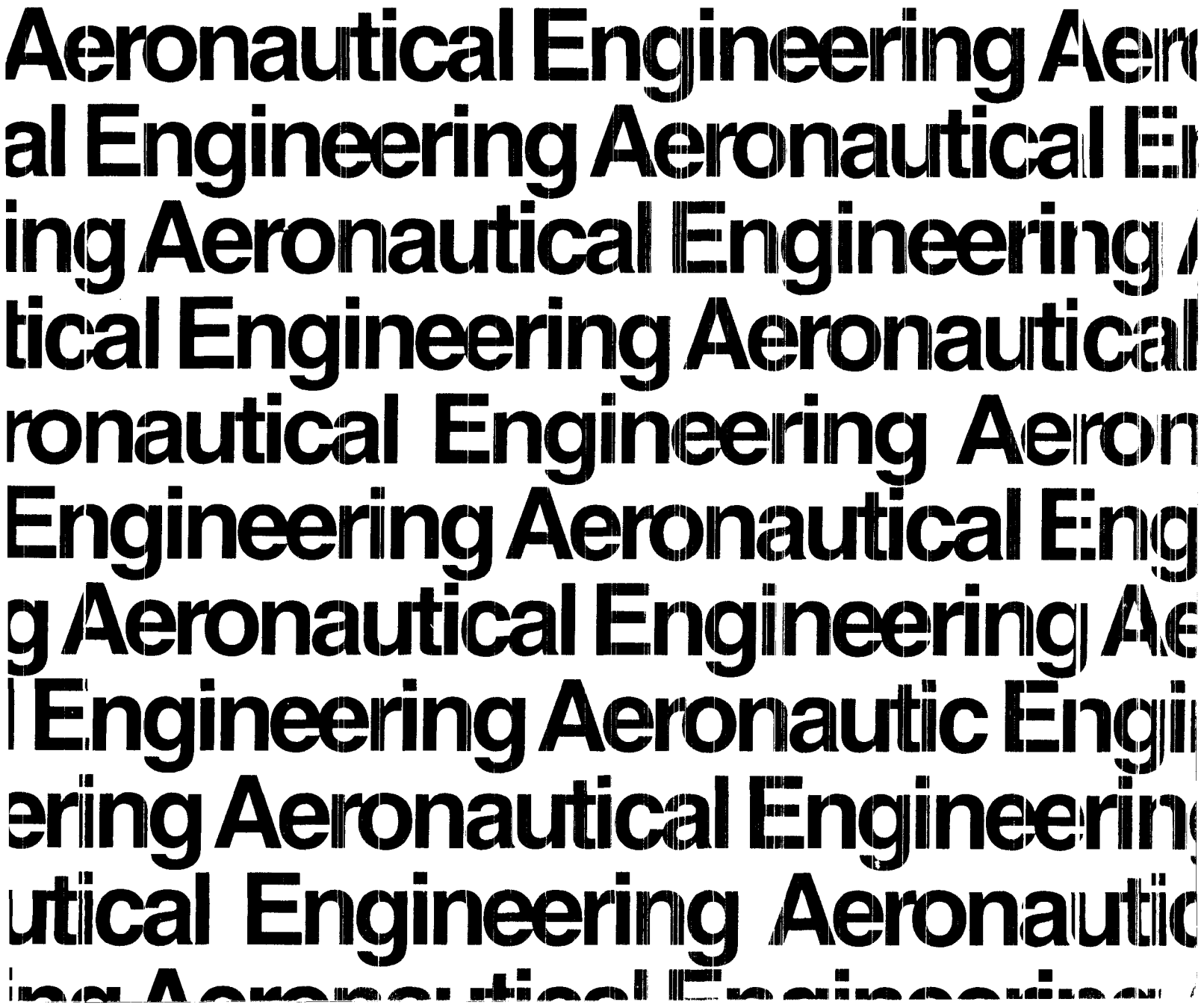
National Aeronautics and Space Administration



NASA SP-7037(255)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 255)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in July 1990 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

National Aeronautics and Space Administration
Office of Management
Scientific and Technical Information Division
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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 529 reports, journal articles and other documents originally announced in July 1990 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cumulative index will be published.

Information on the availability of cited publications including addresses of organizations and NTIS price schedules is located at the back of this bibliography.

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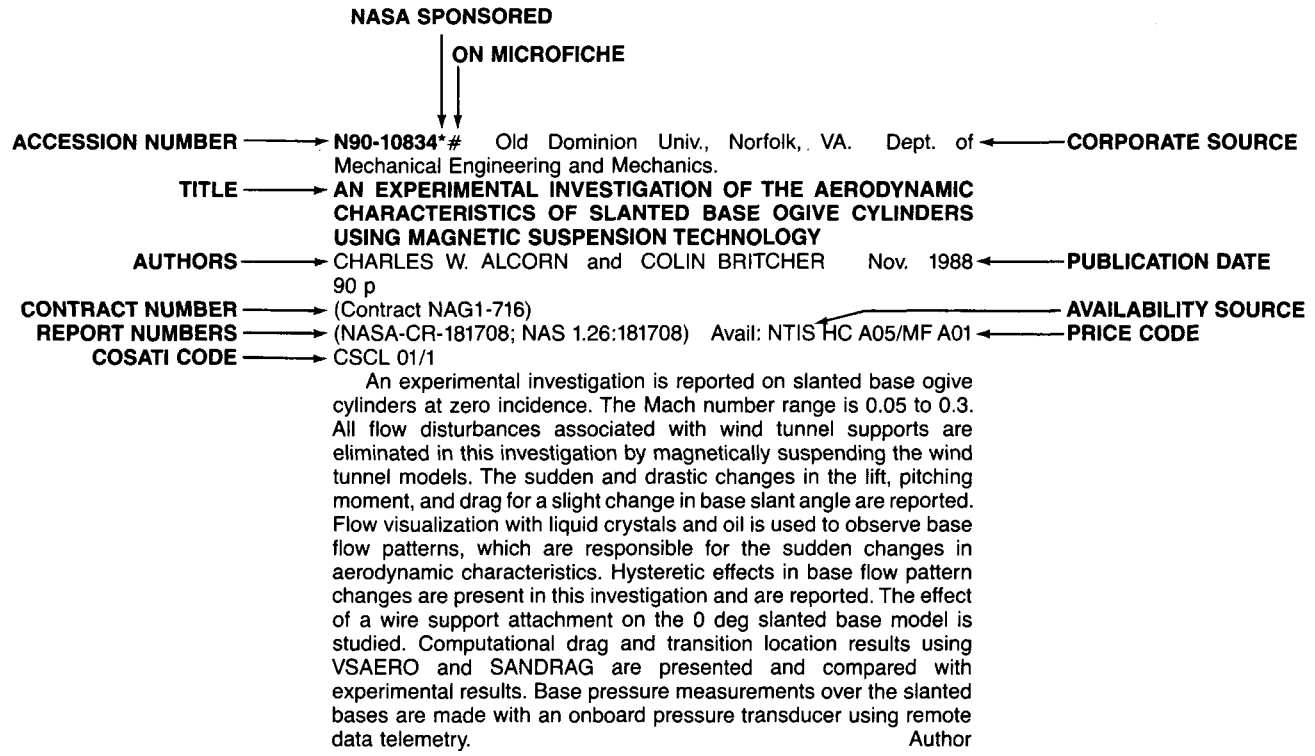
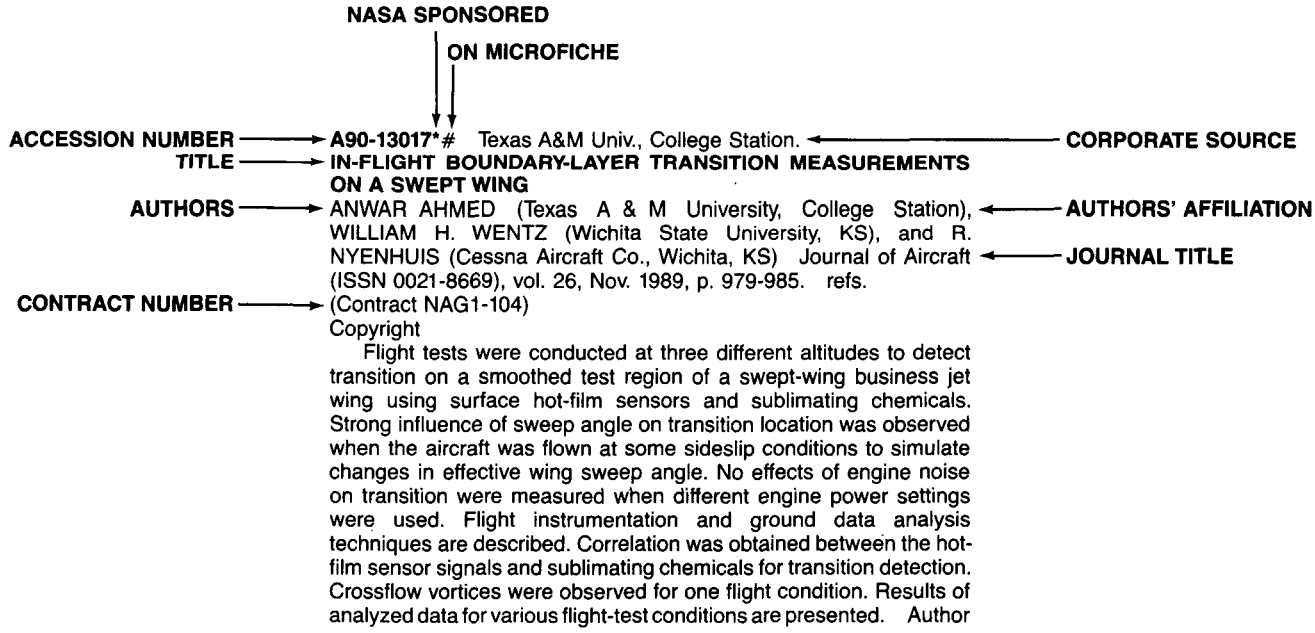
TYPICAL REPORT CITATION AND ABSTRACT



TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 255)

AUGUST 1990

01

AERONAUTICS (GENERAL)

A90-31529
RAPID LOW-TEMPERATURE CURE PATCHING SYSTEM FOR FIELD REPAIR
GEORGE T. SIVY (ITW Adhesive Systems, Danvers, MA) IN: International SAMPE Symposium and Exhibition, 34th, Reno, NV, May 8-11, 1989, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 448-457.
Copyright

A new field repair patch that cures within 1 hour at room temperature is described. The patch forms high strength bonds to metals, thermoplastics, and composites with little or no surface preparation. Under medium load, the patch has good resistance to humidity and temperature. Commonly used solvents and fluids have very little effect on the repair. Shelf-life is over 1 year when stored at, or below, room temperature. Author

A90-31576
ADHESIVE-BONDED COMPOSITE-PATCHING REPAIR OF CRACKED AIRCRAFT STRUCTURE
CHING-LONG ONG and SHYAN SHEN (Chung-Shan Institute of Science and Technology, Taichung, Republic of China) IN: International SAMPE Symposium and Exhibition, 34th, Reno, NV, May 8-11, 1989, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 1067-1078. refs
Copyright

Efforts aimed at the development and validation of a composite-patching repair technology for cracked aircraft structures has characterized three room-temperature-cure adhesives on the basis of single-lap shear tests and fatigue testing. Attention was given to the effects of applying an adhesion-promoter and primer on adhesion strength. After adhesive-bonded repairs with carbon fiber- or boron fiber-reinforced composite patches, the fatigue life of cracked Al alloy panels was found to have been extended by a factor of 60-100. A full-scale fatigue test article experienced 18,000 simulated flight hours without failure. O.C.

A90-31651
DESIGN OF AN AERO-ENGINE THRUST REVERSER BLOCKER DOOR
DAVID MORGAN (British Petroleum, Bristol, England) IN: International SAMPE Symposium and Exhibition, 34th, Reno, NV, May 8-11, 1989, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 2358-2364.
Copyright

An account is given of the application of the resin-transfer molding (RTM) process to fabricate blocker doors for an aircraft engine thrust-reversal system whose manufacturing quality is critical to the achievement of the requisite service life. The use of RTM has in this case facilitated the adoption of an innovative composite design yielding cost and weight reductions over existing Al alloy doors; qualification testing of this carbon fiber cloth-reinforced epoxy resin laminate composite door with integrally molded hinge lugs has been successfully completed. O.C.

A90-31657
SANDWICH STRUCTURES ON AEROSPATIALE HELICOPTERS
JOSEPH SAPORITO (Aerospatiale, Division Helicopteres, Marignane, France) IN: International SAMPE Symposium and Exhibition, 34th, Reno, NV, May 8-11, 1989, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 2506-2513.
Copyright

An account is given of the design features and performance levels of carbon-epoxy stressed outer skin/aramid-reinforced epoxy core sandwich panels for the secondary structures of advanced helicopter airframes, which have been developed in response to strenuous regidity and stability requirements. It is noted that self-adhesive impregnation resins directly bonding the outer skins to the honeycomb core help to economize on adhesive films, yielding a decisive weight reduction advantage over metallic structure alternatives. Attention is given to the adaptation of tooling and NDT methods that these new panels required. O.C.

A90-32275
THE FUTURE OF THE U.S. AIRCRAFT INDUSTRY
ARTEMIS MARCH (Harvard University, Cambridge, MA) Technology Review (ISSN 0040-1692), Jan. 1990, p. 27-34, 36.
Copyright

The major factors that face aviation manufacturers in the U.S. are discussed. Among these factors are: competition from an effective European consortium that is building and marketing products worldwide, enormous financial risks with launch costs for a new aircraft running between two and four billion dollars, development, testing, and certification of airframes and engines that have 20 or more years of service life, launch decisions that are taken with a 25 year perspective and under conditions of great uncertainty, and the entire ramifications of deregulation. To counteract these mounting problems the aircraft industry and goverment agencies acting with the Aerospace Industries Association are attempting to build a cohesive strategy without asking for any additional government funds. AIA has forged an industry consensus around eight key technologies including sensors, propulsion systems, and artificial intelligence and advanced composites. R.E.P.

A90-33094
EXPERT SYSTEMS FOR DESIGN OF BATTLE DAMAGE REPAIRS
STEVEN M. DODD and HERB SMITH, JR. (McDonnell Aircraft Co., Saint Louis, MO) IN: International SAMPE Technical Conference, 21st, Atlantic City, NJ, Sept. 25-28, 1989, Proceedings. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 239-248. refs
Copyright

An expert system advisor designs bolted and bonded repairs of battle damaged wing skins. The system requires very simple input, such as the damage size and location, and the repair materials, and produces an optimized patch design based on the load requirements. The system works by proposing an initial patch

design and iterating toward an acceptable design. The iteration is based on information from several analysis codes and was the expertise of repair design specialists. Author

A90-33125
FABRICATION OF AIRCRAFT STRUCTURES FROM THERMOPLASTIC DRAPEABLE PREFORMS
JAY SHUKLA (Lockheed Aeronautical Systems Co., Burbank, CA) IN: International SAMPE Technical Conference, 21st, Atlantic City, NJ, Sept. 25-28, 1989, Proceedings. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 700-704.
Copyright

Melt processable thermoplastic unidirectional prepregs lack the 'drape' and 'tack' characteristics of carbon/epoxy prepreg materials required to fabricate complex shapes. The newer drapeable hybridized commingled and cospun fiberforms readily conform to complex shapes and overcome the handling deficiencies of dry and boardy prepregs. Also, recent advances in two- and three-dimensional textile processes allow the making of composite parts in near net-shapes or preforms. They have the potential to reduce overall composite part cost as these processes are being automated. In the present investigation, two blade stiffened panels were fabricated from multi-axial warp knitted/stitched preforms by THERM-X and autoclave processes. In addition, complex contour shapes, including C-130 Nacelle Fairing, were fabricated from commingled fabrics. Further work in fabricating near net-shapes from hybridized drapeable materials and preforms is under way at Lockheed for ducts, frames and complex fuselage components. Author

A90-33174
IN THE SHADOW OF ALOHA
IAN GOOLD Flight International (ISSN 0015-3710), vol. 137, April 18, 1990, p. 35-38.
Copyright

An industry task force is recommending further mandatory maintenance work on aging airliners following the Aloha B-737 structural failure incident. The FAA has almost completed issuing requirements for mandatory structural modifications, based on recommendations from an Airworthiness Assurance Task Force (AATF) involving airlines, manufacturers, and airworthiness authorities. Attention is turning to rules on controlling and preventing corrosion, after a second round of industry recommendations. Other AATF teams have been set up to consider human factors in aircraft design, maintenance and inspection, problems of communicating maintenance information throughout the industry, and priorities in research into the preparation of older aircraft. R.E.P.

A90-33351
EUROPEAN FORUM ON AEROELASTICITY AND STRUCTURAL DYNAMICS, AACHEN, FEDERAL REPUBLIC OF GERMANY, APR. 17-19, 1989, PROCEEDINGS
Forum organized by DGLR, AAAF, and Royal Aeronautical Society; Supported by BMFT. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, 698 p. For individual items see A90-33352 to A90-33415.
(DGLR BERICHT 89-01)

Various papers on aeroelasticity and structural dynamics are presented. The general topics addressed include: unsteady aerodynamics; system identification; rotor dynamics and aeroelasticity, dynamic response, noise structure, and fluid-structure interaction; structural modeling and optimization; active control; and aeroelastic stability. C.D.

N90-20920# Federal Aviation Administration, Washington, DC. Office of Management Systems.
CENSUS OF US CIVIL AIRCRAFT Annual Report, 1988
31 Dec. 1988 365 p
(PB90-120296; AMS-420) Avail: NTIS HC A16/MF A02; SOD HC $17.00 as 050-007-00839-2 CSCL 01/2

Information about the U.S. civil aircraft fleet is presented. Detailed tables of air carrier aircraft and an inventory of registered aircraft by manufacturer and model are included and general aviation aircraft by state and county of the owner. Author

N90-20921*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
JOINT UNIVERSITY PROGRAM FOR AIR TRANSPORTATION RESEARCH, 1988-1989
FREDERICK R. MORRELL, comp. Mar. 1990 202 p Research program held during 1988-1989; sponsored by NASA, Langley Research Center and FAA
(NASA-CP-3063; L-16740; NAS 1.55:3063) Avail: NTIS HC A10/MF A02 CSCL 01/3

The research conducted during 1988 to 1989 under the NASA/FAA-sponsored Joint University Program for Air Transportation Research is summarized. The Joint University Program is a coordinated set of three grants sponsored by NASA Langley Research Center and the Federal Aviation Administration, one each with the Massachusetts Institute of Technology, Ohio University, and Princeton University. Completed works, status reports, and annotated bibliographies are presented for research topics, which include computer science, guidance and control theory and practice, aircraft performance, flight dynamics, and applied experimental psychology. An overview of the year's activities for each university is also presented.

N90-20942*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LASER-VELOCIMETER-MEASURED FLOW FIELD AROUND AN ADVANCED, SWEPT, EIGHT-BLADE PROPELLER AT MACH 0.8
HARVEY E. NEUMAN, JOHN A. SERAFINI, DANIEL Y. WHIPPLE, and BRIAN T. HOWARD May 1985 100 p
(NASA-TP-2462; E-2429; NAS 1.60:2462) Avail: Issuing Activity CSCL 01/2

A laser velocimeter has been used to measure velocities in the flow field around an advanced, eight-blade, high-speed propeller in the NASA Lewis 8- by 6-Foot Supersonic Wind Tunnel. The propeller was nominally 62.23 cm (24.5 in.) in diameter and was operated both at windmill and near the design power condition at a free-stream Mach number of 0.8. The detailed three-dimensional velocity data obtained are being made available here to enable researchers to verify emerging advanced propeller design and analysis codes. Data were obtained at two axial positions ahead of the propeller, at two axial positions downstream of the propeller, and at seven radial positions within the bladed passages extending from the inlet of the blades to downstream of the blade exit. A four-beam laser velocimeter system was configured to measure two velocity components simultaneously. Author

N90-20943*# Sverdrup Technology, Inc., Cleveland, OH.
USERS MANUAL FOR THE NASA LEWIS ICE ACCRETION PREDICTION CODE (LEWICE) Final Report
GARY A. RUFF and BRIAN M. BERKOWITZ May 1990 240 p (Contract NAS3-25266)
(NASA-CR-185129; NAS 1.26:185129) Avail: NTIS HC A11/MF A02 CSCL 01/2

LEWICE is an ice accretion prediction code that applies a time-stepping procedure to calculate the shape of an ice accretion. The potential flow field is calculated in LEWICE using the Douglas Hess-Smith 2-D panel code (S24Y). This potential flow field is then used to calculate the trajectories of particles and the impingement points on the body. These calculations are performed to determine the distribution of liquid water impinging on the body, which then serves as input to the icing thermodynamic code. The icing thermodynamic model is based on the work of Messinger, but contains several major modifications and improvements. This model is used to calculate the ice growth rate at each point on the surface of the geometry. By specifying an icing time increment, the ice growth rate can be interpreted as an ice thickness which is added to the body, resulting in the generation of new coordinates. This procedure is repeated, beginning with the potential flow calculations, until the desired icing time is reached. The operation

of LEWICE is illustrated through the use of five examples. These examples are representative of the types of applications expected for LEWICE. All input and output is discussed, along with many of the diagnostic messages contained in the code. Several error conditions that may occur in the code for certain icing conditions are identified, and a course of action is recommended. LEWICE has been used to calculate a variety of ice shapes, but should still be considered a research code. The code should be exercised further to identify any shortcomings and inadequacies. Any modifications identified as a result of these cases, or of additional experimental results, should be incorporated into the model. Using it as a test bed for improvements to the ice accretion model is one important application of LEWICE. Author

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A90-32067#
NUMERICAL SIMULATION OF SEPARATED FLOW AROUND TWO-DIMENSIONAL WING SECTION BY A DISCRETE VORTEX METHOD
SHIGERU ASO, NAOKI FUTATSUDERA (Kyushu University, Fukuoka, Japan), and MASANORI HAYASHI (Nishinippon Institute of Technology, Fukuoka, Japan) (Institute of Space and Astronautical Science and Japan Association for Heat Pipes, Symposium on Mechanics for Space Flight, Sagamihara, Japan, Nov. 24, 25, 1988) Institute of Space and Astronautical Science, Report (ISSN 0285-6508), SP no. 9, March 1989, p. 11-20. refs

Separated flows around pitching wing sections are simulated numerically by a discrete vortex method combined with a panel method. The potential flows around wing sections is expressed by vortex sheets and separated shear layers are expressed by discrete vortices. In the calculation a separation point is determined by solving boundary layer equation. The strength of shed vortex is estimated using local velocity near separatation point. Also modification for the estimation of pressure coefficients around wing section are proposed. The estimated pressure distributions show good agreements with experimental results. Also separated flows around pitching airfoils are simulated. A hysteresis of lift of airfoil at dynamic stall is obtained. Author

A90-32425#
A CALCULATION OF THE AERODYNAMIC LIFT ACTING ON CASCADE BLADES IN A STEADY, VISCOUS FLOW AT HIGH REYNOLDS NUMBER
HIDETO MURATA Tokyo Denki University, Faculty of Engineering, Research Reports (ISSN 0389-617X), no. 36, Dec. 1988, p. 49-56. In Japanese, with abstract in English. refs

In 1983, Vorus presented a high-Reynolds-number, linear theory for the approximate analysis of two-dimensional steady viscous flows. In this report, the steady theory proposed by Vorus is extended to unsteady viscous flows in order to give a method of calculating the aerodynamic forces and moments acting on stalled vibrating cascade blades. For an application of the present theory, a calculation of the lift on flat plates constituting a cascade in a steady flow is carried out. Calculated results are discussed and are compared with the results of a potential flow theory. Author

A90-32451#
MULTI-ELEMENT AEROFOILS IN VISCOUS FLOW
K. P. SINHAMAHAPATRA and B. C. BASU (Indian Institute of Technology, Kharagpur, India) AIAA Journal (ISSN 0001-1452), vol. 28, May 1990, p. 769, 770. Research supported by the Ministry of Defence of India. refs
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A number of multi-element aerofoils having up to four elements are studied both in inviscid and viscous flow. A viscous flow solution is obtained by applying the viscous inviscid interaction (VII) technique. Both direct and semi-inverse iterative modes of coupling are applied using the transpiration velocity model. The inviscid solution is compared with an exact analytical solution whereas the solution after viscous correction is compared with available experimental results. Author

A90-32453#
EFFECTS OF SPLITTER PLATES ON THE WAKE FLOW BEHIND A BLUFF BODY
VIVEK MANSINGH (Hewlett-Packard Co., Cupertino, CA) and P. H. OOSTHUIZEN (Queen's University, Kingston, Canada) AIAA Journal (ISSN 0001-1452), vol. 28, May 1990, p. 778-783. refs
Copyright

The effects of splitter plates on the wake behind a two-dimensional bluff body with fixed separation points has been experimentally studied for low Reynolds numbers between 350 and 1150. A rectangular cylinder was chosen as a bluff body to have the location of the separation points fixed independent of the flow situation and the air velocity. Three sizes of splitter plates were used; these plates were mounted in the center plane of the cylinder at various distances downstream of the cylinder. Detailed measurements of shedding frequency, base pressure, coherence function, and correlation coefficient were obtained. The results indicate that splitter plates alter the manner of vortex formation in the wake causing a decrease in shedding frequency, an increase in base pressure, and a reduction in the overall drag by up to 50 percent. Author

A90-32457#
NUMERICAL COMPUTATIONS OF TRANSONIC CRITICAL AERODYNAMIC BEHAVIOR
JUBARAJ SAHU (U.S. Army, Ballistics Research Laboratories, Aberdeen Proving Ground, MD) AIAA Journal (ISSN 0001-1452), vol. 28, May 1990, p. 807-816. Previously cited in issue 20, p. 3342, Accession no. A88-48832. refs

A90-32458#
CALCULATION OF INTERNAL FLOWS USING A SINGLE-PASS, PARABOLIZED NAVIER-STOKES ANALYSIS
ROBERT F. KUNZ, CHAE M. RHIE, and ROBERT E. MALECKI (United Technologies Corp., Pratt and Whitney Group, East Hartford, CT) AIAA Journal (ISSN 0001-1452), vol. 28, May 1990, p. 817, 818. Previously cited in issue 04, p. 462, Accession no. A89-16477. refs
Copyright

A90-32461#
STATE-SPACE REPRESENTATION OF UNSTEADY AIRFOIL BEHAVIOR
J. G. LEISHMAN and K. Q. NGUYEN (Maryland, University, College Park) AIAA Journal (ISSN 0001-1452), vol. 28, May 1990, p. 836-844. Research supported by the U.S. Army. refs
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A method is presented to model the unsteady lift, pitching moment, and drag acting on a two-dimensional airfoil operating under attached-flow conditions in a compressible flow. Starting from suitable generalizations and approximations to aerodynamic indicial functions, the unsteady airloads due to an arbitrary forcing are represented in a state-space (differential equation) form. This model is in a form compatible with the aeroelastic analyses of both fixed-wing and rotary-wing systems. An important feature of the method is the inclusion of the compressibility effects. The method is validated against experimentally obtained aerodynamic loads for two-dimensional airfoils undergoing oscillatory plunge, oscillatory pitch, and steady pitch rate (ramp) forcing at various Mach numbers. Author

A90-32462#
UNSTEADY, SEPARATED FLOW BEHIND AN OSCILLATING, TWO-DIMENSIONAL SPOILER
CURTIS F. NELSON, DENNIS J. KOGA, and JOHN K. EATON

(Stanford University, CA) AIAA Journal (ISSN 0001-1452), vol. 28, May 1990, p. 845-852. Previously cited in issue 09, p. 1277, Accession no. A89-25245. refs
(Contract AF-AFOSR-86-0159)

A90-32478#
OSCILLATORY SHOCK MOTION CAUSED BY TRANSONIC SHOCK BOUNDARY-LAYER INTERACTION
B. H. K. LEE (National Research Council of Canada, Ottawa) AIAA Journal (ISSN 0001-1452), vol. 28, May 1990, p. 942-944. refs

Unsteady pressure data were obtained on a supercritical airfoil tested in the high-Reynolds-number Two-Dimensional Test Facility of the National Aeronautical Establishment (Canada). The airfoil was the BGK No. 1 with the design Mach number and the lift coefficient of 0.75 and 0.63, respectively. Unsteady pressure data were obtained from 16 fast-response miniature transducers installed on the upper surface of the airfoil. The results of data analysis disclosed discrete frequency shock-wave oscillations for certain flow conditions beyond the buffet onset boundary. The time it took a disturbance to propagate from the shock to the trailing edge plus the additional time it took for an upstream traveling wave generated at the trailing edge to reach the shock agreed quite closely with the period of shock oscillation measured from unsteady force spectra. The results support the proposed mechanism of self-sustained shock motion observed in transonic shock boundary-layer interaction. I.S.

A90-32479#
VORTEX SHEDDING OVER DELTA WINGS
O. K. REDINIOTIS, H. STAPOUNTZIS, and D. P. TELIONIS (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 28, May 1990, p. 944-946. refs

Experiments were conducted in the Virginia Polytechnical Institute Stability Tunnel and the Department of Engineering Science and Mechanics wind tunnel to investigate the phenomenon of vortex shedding over delta wings. The angle of attack of the wing could be varied between 30 and 80 deg. Hot-wire anemometry data obtained indicate that vortices are shed over delta wings at high angles of attack, just like the cases of other flat surfaces or bluff bodies. Once this aerodynamic phenomenon is set in motion, an aircraft will respond, and interaction between the aerodynamics and the wing attitude will lead to wing rock. I.S.

A90-32509
A STUDY OF THE RADIATION OF HYDROGEN-XENON MIXTURES NEAR MODELS FLYING AT HIGH SUPERSONIC VELOCITIES [ISSLEDOVANIE IZLUCHENIIA SMESEI VODORODA S KSENONOM OKOLO MODELEI, LETIASHCHIKH S BOL'SHIMI SVERKHZVUKOVYMI SKOROSTIAMI]
O. V. ZVEREV and N. N. PILIUGIN (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR) Teplofizika Vysokikh Temperatur (ISSN 0040-3644), vol. 28, Mar.-Apr. 1990, p. 338-344. In Russian. refs

The equilibrium chemical composition is calculated for hydrogen-xenon mixtures at different temperatures and pressures behind a shock wave near a model flying along a ballistic path. For different wavelengths, the spectral absorption coefficients and emissivities of these mixtures are calculated as a function of the composition, velocity, and density of the incoming flow. Expressions are obtained which relate the radiation criterion (inverse Boltzmann number) to the incoming flow parameters. Conditions corresponding to substantial gas mixture cooling behind the shock wave are determined. V.L.

A90-32552
ENTRY OF A FLEXIBLE AIRFOIL INTO A VERTICAL GUST [VKHOZHDENIE GIBKOGO PROFILIA V VERTIKAL'NYI PORYV]
B. A. ERSHOV and R. M. RUBLEVSKAIA Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), Jan. 1990, p. 58-63. In Russian.

The problem of the stability of a flexible aileron in supersonic flow is investigated analytically. The aerodynamic forces are determined from a nonstationary velocity potential, which provides an additional number of summands generalizing the piston theory. The transition process associated with an entry into a gust of the singular shock type is defined. V.L.

A90-32559
NONSTATIONARY HYPERSONIC FLOW PAST A THIN WING OF VARIABLE SHAPE [O NESTATSIONARNOM GIPERZVUKOVOM OBTEKANII TONKOGO KRYLA PEREMENNOI FORMY]
E. L. MATVEEVA and E. A. POTEKHINA Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), Jan. 1990, p. 106-108. In Russian.

Attention is given to the problem of hypersonic flow of a homogeneous nonstationary ideal gas past a thin stationary wing whose surface shape and angle of attack are time dependent. A solution in quadratures is obtained by the thin-shock-layer method in the case where the incoming flow velocity and angle of attack are only slightly time dependent and the head shock is attached to the wing at a single point. A condition is determined for shock-wave flow with the shock wave attached to the wing along its entire edge. V.L.

A90-32567
CONTROL POINT SELECTION IN THE DISCRETE VORTEX METHOD [K VYBORU KONTROL'NYKH TOCHEK V METODE DISKRETNYKH VIKHREI]
D. N. GORELOV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Jan.-Feb. 1990, p. 167-170. In Russian. refs

The paper is concerned with the problem of determining the position of control points near the boundaries of a wing with allowance for the different elements of the vortex layer on the wing and in the wake. A computational scheme is proposed which makes it possible to widely vary the time step in problems of nonstationary separated and nonseparated flow without any reduction in computation accuracy. An example of vortex layer calculation is presented. V.L.

A90-32673
NUMERICAL MODELING OF SEPARATED TURBULENT FLOWS [CHISLENNOE MODELIROVANIE OTRYVNYKH TURBULENTNYKH TECHENII]
A. V. BORISOV and V. B. KARAMYSHEV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Jan. 1990, p. 37-43. In Russian. refs

Results of turbulent flow calculations based on two different turbulent viscosity models are presented. One model is a k-epsilon model using the Jones-Launder differential convective diffusion equation; the other model is a q-omega model using the Coakley equation. The turbulence model equations are integrated using a first-order approximation scheme. Both turbulent viscosity models are shown to provide a sufficiently accurate general flow pattern. A significant difference between the predictions of the k-epsilon and q-omega models is observed only near the body surface, which is explained by the difference in flow modeling for small local Reynolds numbers. V.L.

A90-32712
SOLUTION OF SONIC FLOW PROBLEMS [O RESHENII ZADACH OBTEKANIIA SO SKOROST'IU ZVUKA]
S. K. ASLANOV (Odesskii Gosudarstvennyi Universitet, Odessa,

Ukrainian SSR) Gidromekhanika (ISSN 0367-4088), no. 59, 1989, p. 28-34. In Russian. refs
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The problem of transonic flow past simple profiles formed by straight lines is solved for the symmetric and nonsymmetric cases. In both cases, a singular solution is obtained in the hodograph plane using the Fourier method, with all conditions satisfied in the mixed boundary region. For the emerging infinite systems, regularity is demonstrated, which makes it possible to use the reduction method. An attempt is made to extend the approach proposed here to the rigorous Chaplygin equation. V.L.

A90-32959*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NAVIER-STOKES ANALYSES OF THE REDISTRIBUTION OF INLET TEMPERATURE DISTORTIONS IN A TURBINE
MAN MOHAN RAI (NASA, Ames Research Center, Moffett Field, CA) and ROBERT P. DRING (United Technologies Research Center, East Hartford, CT) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, May-June 1990, p. 276-282. Previously cited in issue 20, p. 3144, Accession no. A87-45432. refs
Copyright

A90-33283#
AN EXPERIMENTAL STUDY ON FLOWFIELDS IN A DUAL INLET SWIRL-DUMP COMBUSTOR
XINYU QIU, XUEREN ZHANG, and XINGZHOU LIU (31st Research Institute, People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), April 1990, p. 7-14. In Chinese, with abstract in English. refs

The flowfields in a dual-inlet swirl-dump combustor in the cold state were studied experimentally to evaluate the effects of flow entrance type (full-swirl or part-swirl), swirl strength (swirl number S or vane angle phi), divergence angle of divergent nozzle of swirl chamber (2alpha), swirl chamber length to diameter ratio (l/d), and inner-channel to whole-channel area ratio (F) on structures of combustor flowfields. The results show that stable central recirculation zones and head votex systems can be established in the combustor through properly selecting combustor geometric parameters. In addition to the swirl-chamber recirculation zones, bigger central recirculation zones without tangential velocities are formed behind them when phi = 45 degrees, alpha = 15 degrees, l/d = 1.3 and F = 0.41. Both recirculation zones are connected with each other. Author

A90-33288#
AN EXPERIMENTAL INVESTIGATION ON CONTROL OF FLOW DYNAMIC DISTORTIONS DOWNSTREAM UNDER STRONG SHOCK-BOUNDARY LAYER INTERACTION IN THE TWO-DIMENSIONAL FLOW FIELD
ZHONGWEI HE (Nanjing Aeronautical Institute, People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), April 1990, p. 35-39. In Chinese, with abstract in English.

Flow-dynamic distortions due to a strong shock with Mach 1.68-1.74 turbulent boundary-layer interaction in a two-dimensional convergent-divergent duct are investigated, under some conditions on the boundary layer, including the effects of bleed-slot structures and the slot locations on flow-dynamic distortion downstream of the interaction. Also analyzed are (1) the power-spectral density and probability density of the total pressure signals and (2) the pressure time history at several particular locations along the profiles of the flow turbulence distribution at the exit of the divergent section of duct. The experimental results show that the distortion downstream of the interaction region can be efficiently improved by bleeding the shock-induced separate flow in the interaction region with a bleed flow of 2.8-3.5 percent. Author

A90-33311*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
UNSTEADY AIRLOADS DUE TO SEPARATED FLOW ON AIRFOILS AND WINGS
JOHN W. EDWARDS (NASA, Langley Research Center, Hampton, VA) NATO, AGARD, Specialists' Meeting on Aircraft Dynamics Loads Due to Flow Separation, 70th, Sorrento, Italy, Apr. 1-6, 1990, Paper. 19 p. refs

Experimental and computational studies of airloads due to separated flows over airfoils and wings conducted at the NASA Langley Research Center are surveyed. Results are presented for cases involving local flow separation such as shock-induced separation, for the initiation of leading-edge vortex flows, and for cases involving unsteady airloads due to flows separating over remote aircraft components. Good correlation is obtained between experiment and computation for cases of locally separating flow and steady computations of vortex flow over delta wings and complex forebody geometries are shown. Physical flow modeling issues and computational requirements for the case of vertical tail buffeting are developed. Author

A90-33353*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
UNSTEADY AERODYNAMICS METHODS FOR TRANSONIC AEROELASTIC ANALYSIS
JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 15-24. refs

The paper describes the current status of methods development for transonic aeroelastic analysis within the Unsteady Aerodynamics Branch at NASA Langley. The paper first highlights the development of an approximate factorization (AF) algorithm for solution of the unsteady transonic small-distribution (TSD) equation. The AF algorithm has been used as the basis for a three-dimensional TSD code for complete aircraft applications. The paper also describes the development of solution algorithms for the unsteady Euler equations based on the use of unstructured meshes. These Euler methods contain a dynamic mesh algorithm, which is a general procedure to move or deform the mesh so that it continuously conforms to the instantaneous shape of the aeroelastically deformed vehicle. Author

A90-33355#
A STRONG VISCOUS-INVISCID INTERACTION METHOD FOR COMPUTING UNSTEADY TRANSONIC AIRLOADS FOR USE IN AEROELASTICS
K. DAU, U. R. MUELLER, and H. HENKE (MBB GmbH, Bremen, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 35-42. refs

Recent developments toward a new, time-accurate strong interaction method for computing unsteady transonic airfoil flow are reported. An ADI-technique for solving the unsteady Transonic Small Perturbation Equation has been extended by incorporating an integral boundary layer method and then simultaneously solving the viscous and inviscid flow equations at each streamwise station. Time-accuracy is achieved by repeated Y-sweeps per time step. The strong-interaction technique is validated first by calculations of subsonic steady airfoil flows, including one about a deflected spoiler, and by comparison with experimental data and other computations. Adequacy of the purely inviscid TSP-method to compute steady and unsteady transonic flow is demonstrated by comparison calculations with Full-Potential as well as Euler methods. Finally, the interactive computation of the transonic flow about the supercritical NLR 7301 airfoil oscillating in pitch is shown to compare well with experimental data. Author

A90-33356#
COMPARISON OF TWO POTENTIAL FLOW METHODS FOR TRANSONIC FLUTTER ANALYSIS
B. SCHULZE and S. VOGEL (MBB GmbH, Bremen, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 43-49. refs

Three-dimensional unsteady transonic airloads are computed by two methods and compared with each other. The frequency-domain PTRAN3 code is based on the time-linearized Transonic Small Disturbance Equation (TSD), while the Dau-Garner-Method corrects linear unsteady pressures by means of quasisteady transonic pressure distributions. Special emphasis is put on the steady flow field that is required as an input for the PTRAN 3 code. An inverse method (NEWTSD) has been developed in order to compute a TSD-approximation of the steady flow field for a given (measured) pressure distribution. The methods are validated with experimental data of the LANN wing. Results of flutter calculations are presented for a supercritical aircraft wing. Author

A90-33357#
COMPUTATION OF UNSTEADY TRANSONIC FLOWS AROUND OSCILLATING AIRFOILS USING FULL POTENTIAL AND EULER EQUATIONS

R. VOSS and V. CARSTENS (DLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 51-64. refs

The numerical results of two codes for computing the unsteady transonic flow around an oscillating airfoil in pitching motion are presented, namely of an Euler code using flux vector splitting and a Full Potential method including entropy correction. After a description of the basic equations and the numerical techniques used by both codes, results are presented for the instantaneous pressure distribution of different phase angles of the airfoil's motion and for the time history of the lift coefficient. The computed results of both codes are compared with each other and with the experimental data of an AGARD standard test case. Special attention is directed to the behavior of unsteady pressure and lift with respect to a change in the reduced frequency k. To demonstrate the influence of this parameter, results are shown for four different k-values between 0.05 and 1.0. Author

A90-33358#
APPLICATIONS OF THE UNSTEADY FULL POTENTIAL EQUATION FOR WINGS

B. WINZELL (Saab-Scania, AB, Linkoping, Sweden) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 65-83. Research supported by Saab-Scania, AB and Forsvarets Materielverk. refs

The classic linear theory is compared to the nonlinear unsteady theory, with emphasis on a finite difference program for the full potential equation applied to several three-dimensional wings. The program predictions of pressure distribution, integrated loads, and flutter are compared with experiment data and linear theory calculations. It is noted that although at transonic conditions the detailed pressure distributions from the full potential program look different from those of the linear method, integrated loads for flutter calculations are predicted with the same degree of accuracy; and while the full potential approach enables a simulation of the physical flow structure at transonic speeds with weak shocks, the point-wise agreement with data is less sufficient in cases where a more complicated theory than the linear one is desirable. V.T.

A90-33359#
CALCULATION OF UNSTEADY SUBSONIC AND SUPERSONIC FLOW ABOUT OSCILLATING WINGS AND BODIES BY NEW PANEL METHODS

M. H. L. HOUNJET (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 85-103. Research supported by the Royal Netherlands Air Force. refs

Unsteady aerodynamic loads in the subsonic and supersonic domain have been obtained with two new panel methods for lifting surfaces and for realistic aircraft configurations. A description of the methods is given. Results are presented and comparisons are made with results of existing methods and with experimental data for a fighter-type wing with external stores. Author

A90-33360#
TWO-DIMENSIONAL COMPRESSIBLE UNSTEADY AERODYNAMICS IN THE LAPLACE DOMAIN

P. GARCIA-FOGEDA (Escuela Tecnica Superior de Ingenieros Aeronauticos, Madrid, Spain) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 105-112. Research sponsored by the Ministerio de Educacion y Ciencia of Spain. refs

A pressure mode method to obtain the unsteady aerodynamic forces for airfoils in arbitrary motions is presented. The forces are evaluated numerically in the Laplace domain by an efficient method for computing the kernel. In the frequency domain the present method is validated by numerical results for oscillating airfoils and airfoils with oscillating flaps. The root locus for a three-degrees-of-freedom airfoil is also calculated and compared with the generalized to the s-plane Theodorsen function. Comparisons with other results and discussions are given. Author

A90-33361#
A COMPARISON BETWEEN THEORETICAL AND EXPERIMENTAL RESULTS FOR A 3-D WING WITH DAMPED PITCHING OSCILLATIONS

L. P. RUIZ-CALAVERA, D. SCHOLZ (Instituto Nacional de Tecnica Aeroespacial, Torrejon de Ardoz, Spain), W. GEISSLER, H. TRIEBSTEIN, and J. WAGENER (DLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 113-121. refs

Unsteady airloads are analyzed on a three-dimensional wing model undergoing damped pitching oscillations in a subsonic flow. In addition to the experimental data, corresponding theoretical results are obtained by means of an unsteady three-dimensional panel working in the time domain. Mean incidences, initial displacements and mean velocities are varied, and the measured incidence variations of the wing are used as input for the unsteady calculation procedure in order to facilitate direct comparisons between measured and calculated results. In most of the test cases the experimental data closely correspond to the numerical results. Larger deviations occur in the immediate leading-edge region at instantaneous incidences alpha (t) equal or greater than seven degrees. V.T.

A90-33362#
CALCULATIONS OF UNSTEADY AERODYNAMICS OVER OSCILLATING WINGS

JIRO NAKAMICHI (National Aerospace Laboratory, Chofu, Tokyo, Japan) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 123-131. refs

Unsteady aerodynamics over oscillating wings are studied. A flow model based on time-averaged thin-layer Navier-Stokes equations is utilized, with the equations solved by a diagonal Beam-Warming technique. Calculations are carried out on dynamic grids in order to satisfy the nonslip conditions on the moving surfaces. The NORA and LANN wings oscillating in pitch motions are computed, and two-dimensional simulations are also performed. It is shown that the code produces good results for the cases where the flow is not separated. As for shock wave motions, it is difficult to predict the shock-boundary layer interactions; solutions can be improved by increasing the grid point near the shock wave. V.T.

A90-33363#
UNSTEADY AERODYNAMIC FORCES OF OSCILLATING SUPERSONIC/HYPERSONIC WINGS WITH ATTACHED SHOCK WAVES
JING-SONG CHEN (Nanjing Aeronautical Institute, People's Republic of China) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 143-149. refs

A local-flow piston theory applied to the development of the unsteady-pressure coefficient formula is utilized for pointed leading-edge airfoils performing a harmonic pitching and plunging oscillation. Oscillating derivative formulas for flutter analysis and stability analysis are obtained; these formulas are in agreement with the supersonic and hypersonic flow theories. Two-dimensional wing solutions for the local-flow piston theory together with the strip theory approximation are used to obtain oscillation derivative formulas for three-dimensional wings with a pointed leading-edge airfoil section and a general planform at arbitrary mean angles of attack in a case when the shock wave is attached to the leading edge of the wing. Variations of unsteady aerodynamic forces with a free stream Mach number, mean angle of attack, sweep angle, and aspect of attack are assessed. V.T.

A90-33364#
NUMERICAL ANALYSIS OF UNSTEADY FORCES ON OSCILLATING RING AIRFOILS AND JET ENGINES
EDGAR KATZER (DLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 151-158. refs

Unsteady potential flows over thin jet engines and ring airfoils in harmonic pitch and heave oscillations are investigated. A new Fourier panel method leads to a system of one-dimensional integral equations and reduces the numerical efforts by an order of magnitude. The unsteady flow is calculated by a time-marching procedure. A vortex cylinder emanating from the trailing edge of the engine nacelle simulates the jet. Jet influences on the unsteady aerodynamic forces are found to be small for small and moderate engine diameters, but they increase considerably with increasing diameter. Author

A90-33365#
UNSTEADY LIFT AND MOMENT COEFFICIENTS OF AN ENGINE NACELLE
W. SEND (DLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 159-168. refs

Unsteady lift and moment coefficients obtained for an annular wing with a diameter-to-length ratio ranging from 0.5 to 2.0 are presented. The degrees of freedom considered represent harmonic pitching and plunging motions. The reduced frequency based on a half cord length varies from steady flow conditions to a reduced frequency equal 2. The results are compared with experimental data obtained from an engine model with a diameter-to-length ratio of 0.5. The mean powers occurring during one cycle of motion at two degrees of freedom (pitch and plunge) are assessed. The sign of each individual power load serves as an instrument for detection of instabilities in a mechanical system under the influence of aerodynamic forces. Stability charts show a large domain of complete instability, i.e. simultaneous consumption of power from the surrounding airstream for both degrees of freedom. V.T.

A90-33366#
EXPERIMENTAL INVESTIGATION OF THE FLOW DEVELOPMENT OF AN AIRFOIL AT HIGH ANGLES OF ATTACK
W. KERRES and H. GROENIG (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 169-177. refs
(Contract DFG-SFB-25)

The flow development on a NACA 0012 airfoil under stall condition is investigated. A special water tunnel allows to accelerate the flow in the test section to a steady velocity within the range of milliseconds. Due to the absence of turbulence during flow start, the development of the vortex system can be shown in detail. Experimental techniques applied are visualization, velocity measurements and measurement of the unsteady forces and pitching moment acting on the profile. The starting vortex and the small vortices, which leave the airfoil when stall sets on, are subject of the investigations presented in the last part. Author

A90-33368#
AN INVESTIGATION OF THE BUFFET EXCITATION PARAMETER
D. J. MAULL and S. J. ZAN (Cambridge, University, England) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 187-194. Research supported by the Royal Aerospace Establishment.

The buffet excitation parameter is measured in a low-speed wind tunnel for a series of simple rectangular planform wings of different aspect ratios and generalized masses for angles of incidence up to forty degrees. Only first mode bending is considered, and it is shown that for angles of incidence close to that at which there is a peak in the normal force curve, there appears to be a small increase in the buffet excitation parameter with increasing frequency. For all aspect ratios the parameter first peaks at an angle of incidence of about ten degrees with a parameter value of between 0.003 and 0.004. Higher aspect ratio wings produce a further peak at about 0.007 at an incidence of about thirty degrees and the value of this peak decreases with decreasing aspect ratio. There are some indications that even for a constant planform wing the parameter is a function of the reduced wing bending frequency. V.T.

A90-33410#
FURTHER STUDIES OF HARMONIC GRADIENT METHOD FOR SUPERSONIC AEROELASTIC APPLICATIONS
P. C. CHEN (Zona Technology, Inc., Mesa, AZ), D. D. LIU, D. K. JAMES (Arizona State University, Tempe), and A. S. POTOTZKY (Planning Research Corp., Hampton, VA) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 605-620. refs

Recent development in Arizona in the applications of the Harmonic Gradient Method (HGM) to various lifting surfaces with/without control surfaces are described. Special emphasis is placed on the validation of the acceleration potential version of HGM, also known as the ZONA51 code, with available measured data and existing methods which include ASTROS, the Pressure Mode Method and Piston theory. Control-surface aerodynamics and flutter analysis were studied for cases of different planforms. For all cases considered, the present results are found in good agreement with the measured unsteady pressures; computed flutter results are also found to follow closely with those measured. Author

A90-33411#
THE EFFECT OF WINGLETS ON AIRCRAFT WING FLUTTER
G. BUTT (Carl Schenk AG, Darmstadt, Federal Republic of Germany) and A. DAFNIS (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 621-632. refs

An experimental method is presented for measuring unsteady

forces on a model wing with and without winglets. The reactions on the wing root, wing tip, or winglet (force, bending-moment, and torsional moment), as well as the aileron-moment were measured by applying a forced excitation to the model in three degrees of freedom (roll, pitch, and aileron motion). The flutter calculations on experimental data resulted in lower damping factors than the strip-theory calculations, due to the too large aerodynamic forces from the two-dimensional theory. The paper discusses the in-flight measurements that will be performed in the near feature in order to evaluate and complete the wind-tunnel test results. In addition, the flight-safety measures and considerations for the Morane aircraft with winglets are discussed. I.S.

A90-33506
TRANSITION FROM ORDER TO CHAOS IN THE WAKE OF AN AIRFOIL
K. WILLIAMS-STUBER and M. GHARIB (California, University, La Jolla) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 213, April 1990, p. 29-57. Research sponsored by DARPA. refs
(Contract N00014-86-K-0758)
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An experimental effort is presented here that examines the nonlinear interaction of multiple frequencies in the forced wake of an airfoil. Wakes with one or two distinct frequencies behave in an ordered manner - being either locked or quasi-periodic. When a third incommensurate frequency is added to the system, the flow demonstrates chaotic behavior. Previously, the existence, of the three-frequency route to chaos has been reported only for closed system flows. It is important to note that this chaotic state is obtained at a low Reynolds number. However, the chaotic flow shows localized characteristics similar to those of high Reynolds number turbulent flows. The degree of chaotic behavior is verified by applying ideas from nonlinear dynamics (such as Liapunov exponents and Poincare sections) to the experimental data, thus relating the basic physics of the system to the concepts of mode interaction and chaos. Significant changes to the vortex configuration in the wake and to the rms velocity profile occur during the transition from order to chaos. Author

A90-33509* Manchester Univ. (England).
NON-AXISYMMETRIC VISCOUS LOWER-BRANCH MODES IN AXISYMMETRIC SUPERSONIC FLOWS
PETER W. DUCK (Manchester, Victoria University, England) and PHILIP HALL (Exeter, University, England) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 213, April 1990, p. 191-201. refs
(Contract NAS1-18107)
Copyright

A previous paper by Duck and Hall (1989) considered the weakly nonlinear interaction of a pair of axisymmetric lower-branch Tollmien-Schlichting instabilities in cylindrical supersonic flows. Here, the possibility that nonaxisymmetric modes might also exist is investigated. In fact, it is found that such modes do exist and, on the basis of linear theory, it appears that these modes are the most important. The nonaxisymmetric modes are found to exist for flows around cylinders with nondimensional radius a less than some critical value a(c). This critical value a(c) is found to increase monotonically with the azimuthal wavenumber n of the disturbance, and it is found that unstable modes always occur in pairs. It is shown that, in general, instability in the form of lower-branch Tollmien-Schlichting waves will occur first for nonaxisymmetric modes and that, in the unstable regime, the largest growth rates correspond to the latter modes. Author

A90-33514
MODIFICATION OF LARGE EDDIES IN TURBULENT BOUNDARY LAYERS
SHI-ING CHANG and RON F. BLACKWELDER (Southern California, University, Los Angeles) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 213, April 1990, p. 419-442. refs
(Contract F49620-85-C-0080)
Copyright

Turbulent boundary layers were altered with a tandem array of manipulators arranged to produce a maximum drag reduction. The Reynolds number based on the momentum thickness, Re(theta), at the first manipulator position was between 1700 and 2400. Temperature was used as a passive contaminant to explore the dynamical relationship between the near-wall and outer regions of the manipulated layer. Heat was introduced by warming the wall uniformly to 15 C above the ambient temperature or with a line heater in the wake of the manipulator. Temperature and velocity measurements showed a reduction in fluctuation amplitude and a strong decrease in larger scale mixing accompanied by a reduction of the Taylor microscale and integral lengthscale. Isocorrelations indicated that the eddy size was decreased in all three directions. The net result of the manipulators was a marked decrease in the entrainment of irrotational fluid into the boundary layer. The results suggest that the manipulators do not directly affect the wall region but rather decrease the entrainment, and hence the growth of the boundary layer, leading to possible drag reduction. Author

A90-33515
AN EXPERIMENTAL INVESTIGATION OF THE TURBULENT STRUCTURE IN A TWO-DIMENSIONAL MOMENTUMLESS WAKE
J. M. CIMBALA and W. J. PARK (Pennsylvania State University, University Park) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 213, April 1990, p. 479-509. Research supported by the Engineering Foundation. refs
(Contract NSF MSM-87-07653)
Copyright

The rapid decay of turbulence downstream of a two-dimensional momentumless body were investigated with the emphasis placed on measurements of the mean velocity profiles and the turbulence intensities and on smoke-wire flow visualizations caried out at several downstream locations in the wake to document the geometry and the scale of the turbulent structure. Four cases were documented: (1) a pure wake (no injection), (2) a weak wake (some injection), (3) a momentumless wake (injection adjusted to provide a thrust which exactly cancels the model's drag), and (4) a weak jet (more injection than necessary to cancel the drag). The mean velocity profiles clearly show the difference in the momentum deficit for the four cases. The decay rate of the centerline velocity difference was found to be much faster than that of the pure wake or pure jet. Consequently, fast decay of the mean shear was also observed. I.S.

A90-33560#
THE INFLUENCE OF BOUNDARY LAYER STATE ON VORTEX SHEDDING FROM FLAT PLATES AND TURBINE CASCADES
C. H. SIEVERDING (Institut von Karman de Dynamique des Fluides, Rhode-Saint-Genese, Belgium) and H. HEINEMANN (DLR, Goettingen, Federal Republic of Germany) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 112, April 1990, p. 181-187. refs
(ASME PAPER 89-GT-296) Copyright

The paper aims at a better understanding of the reasons for the wide range of Strouhal numbers observed on turbine blades. The investigation is restricted to the subsonic domain. First, flat plate model tests are carried out to investigate the effect of both the boundary layer state and trailing edge geometry on the vortex shedding frequency. A particular objective of the tests is to obtain data for the very common case of a mixed laminar-turbulent separation from turbine blades. These basic tests are followed by three cascade tests with blades of very different suction side velocity distributions. Based on the experience gained from the flat plate test program, an attempt is made to interpret the Strouhal number variation with Mach number and Reynolds number, and to relate the vortex frequency change to the boundary layer state on the blade surfaces. Author

A90-33562#
UNSTEADY TRANSITION IN AN AXIAL-FLOW TURBINE. I - MEASUREMENTS ON THE TURBINE ROTOR. II - CASCADE MEASUREMENTS AND MODELING
J. S. ADDISON and H. P. HODSON (Cambridge, University,

England) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 112, April 1990, p. 206-221. Research supported by Rolls-Royce, PLC. refs
(ASME PAPER 89-GT-289; ASME PAPER 89-GT-290) Copyright

Previously published measurements in a low-speed, single-stage, axial-flow turbine have been reanalyzed. The measurements include time-resolved hot-wire traverses and surface hot film gas measurements at the midspan of the rotor suction surface with three different rotor-stator spacings. The suction surface boundary layer transition process, using surface-distance time plots and boundary layer cross sections to demonstrate the unsteady and two-dimensional nature of the process is investigated. Results of supporting experiments carried out in a linear cascade together with a simple transition model, which explains the features seen in the turbine, are described. R.E.P.

A90-33563#
AN IMPROVED INCIDENCE LOSSES PREDICTION METHOD FOR TURBINE AIRFOILS

S. H. MOUSTAPHA, S. C. KACKER (Pratt and Whitney Canada, Longueuil), and B. TREMBLAY (Carleton University, Ottawa, Canada) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 112, April 1990, p. 267-276. refs
(ASME PAPER 89-GT-284) Copyright

The off-design performance of axial turbines is usually predicted by calculating the incidence losses using empirical correlations. Periodic review and improvement to these prediction methods, to reflect recent turbine designs and test results, are essential for the accurate assessment of losses in turbine airfoils. The purpose of the present work is to evaluate existing turbine incidence loss correlations, and present an improved prediction method for profile and secondary losses at off-design conditions which correlates better with the available experimental results. The incidence losses are shown to be a function of leading edge diameter, pitch, aspect ratio and channel convergence. Author

A90-33564#
THE TRAILING EDGE LOSS OF TRANSONIC TURBINE BLADES

J. D. DENTON (Cambridge, University, England) and L. XU (Beijing University of Aeronautics and Astronautics, People's Republic of China) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 112, April 1990, p. 277-285. refs
(ASME PAPER 89-GT-278) Copyright

Recent findings that the base pressure and loss can be reasonably well predicted by inviscid Euler calculations are justified and explained. For unstaggered choked blading, it is shown that there is a unique relationship between the back pressure and the base pressure and any calculation that conserves mass, energy and momentum should predict this relationship and the associated loss exactly. For realistic staggered blading, which operates choked but with subsonic axial velocity, there is also a unique relationship between the back pressure and the base pressure (and hence loss) but the relationship cannot be quantified without knowing a further relationship between the base pressure and the average suction surface pressure downstream of the throat. It is shown that suction surface curvature downstream of the throat may be highly beneficial in reducing the loss of blades with thick trailing edges operating at high subsonic or low supersonic outlet Mach numbers. R.E.P.

A90-33567#
INLET DISTORTION GENERATED PERIODIC AERODYNAMIC ROTOR RESPONSE

S. R. MANWARING and S. FLEETER (Purdue University, West Lafayette, IN) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 112, April 1990, p. 298-307. refs
(Contract F49620-88-C-0022)
(ASME PAPER 89-GT-299) Copyright

Fundamental inlet distortion-generated rotor blade row unsteady aerodynamics, including the effects of both the detailed aerodynamic forcing function for the first time and steady loading are experimentally investigated in an extensively instrumented axial-flow research compressor. A two-per-rev forcing function with three gust amplitude ratios is generated. On the rotor blade pressure surface, the unsteady pressure nondimensionalization compresses the magnitude data with mean flow incidence angle. This is not the case on the higher camber suction surface. These pressure surface unsteady data are primarily affected by the steady loading level, whereas the suction surface unsteady data are a function of the steady loading level and distribution as well as the gust amplitude ratio. In addition, a design inlet distortion blade surface unsteady pressure correlation is considered. Author

A90-33568#
VISUALIZATION STUDIES IN ROTATING DISK CAVITY FLOWS

J. NORDQUIST, S. ABRAHAMSON, J. WECHKIN, and J. EATON (Stanford University, CA) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 112, April 1990, p. 308-310. Research supported by the Garrett Turbine Engine Co. and General Motors Corp.
(Contract NSF MEA-83-51417)
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An experimental study was performed in a simplified turbine disk cavity consisting of a single disk rotating near a stationary flat plate, bounded radially by an axial seal fixed to the plate. The disk Reynolds number was 620,000. Cooling flow was supplied axially at a dimensionless radius of 0.33. Flow visualization showed boundary layers on both the rotating and stationary disks with the core between the layers rotating in solid body motion. At intermediate cooling flow rates, large vortical structures aligned with the disk spin axis and spanning the core were observed. Author

A90-33700
AN INVESTIGATION OF THE FLOW CHARACTERISTICS OF TRANSONIC NOZZLE BLADES

V. D. VENEDIKTOV, A. V. GRANOVSKII, and A. N. KOLESOV (Tsentral'nyi Nauchno-Issledovatel'skii Institut Avaitsionnogo Motorostroeniia, Moscow, USSR) (Teploenergetika, vol. 36, no. 8, 1989, p. 53-56) Thermal Engineering (Teploenergetika) (ISSN 0040-6015), vol. 36, Aug. 1989, p. 452-455. Translation. refs
Copyright

The effects of changes in the shape of the oblique section of a transonic annular nozzle cascade on the flow rate are investigated theoretically and experimentally. The design parameters for two basic cascade configurations are listed in a table, and the results of theoretical analyses are compared with measurement data in graphs. When the convergence of the outlet section is high and the cascade design angle is less than the effective angle, significant discrepancies (3-5 percent) are found between the measured flow rates and those predicted under the assumptions of uniform flow and coincidence of the critical and minimum blading cross sections. It is shown that this error can be reduced by accounting for the two- or three-dimensional flow patterns in the throat section and the displacement thickness of the blading boundary layers. T.K.

A90-33753#
NUMERICAL SIMULATION OF SEPARATED FLOWS AROUND A WING SECTION AT PITCHING MOTION BY A DISCRETE VORTEX METHOD

SHIGERU ASO, ATSUSHI FUJIMOTO, NAOKI FUTATSUDERA, and MASANORI HAYASHI Kyushu University, Technology Reports (ISSN 0023-2718), vol. 63, Jan. 1990, p. 71-77. In Japanese, with abstract in English. refs

Separated flows around a wing section at pitching motion are simulated numerically by a discrete vortex method combined with a panel method. The potential flows around wing sections are expressed by vortex sheets and separated shear layers are expressed by discrete vortices. In the calculation a separation point is determined by solving boundary layer equations. The strength of shed vortex is estimated using local velocity near separation point. Separated flows around pitching airfoils are simulated. A hysteresis of lift of airfoil at dynamic stall is obtained

in the calculation. These results suggest that this method is useful to simulate separated flows around a wing section at pitching motions. Author

A90-34323#
NUMERICAL SIMULATION OF VORTEX BREAKDOWN BY SOLVING THE EULER EQUATIONS FOR AN INCOMPRESSIBLE FLUID
T. H. LE, P. MEGE (ONERA, Chatillon-sous-Bagneux, France), and Y. MORCHOISNE (Paris VI, Universite, Paris; ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 5, 1989, p. 35-49. Research sponsored by DRET and DGA. refs
Copyright

A method of calculating unsteady, three-dimensional flows of inviscid incompressible fluid has been used in research on vortex breakdown. This method is based on the solution of the unsteady Euler equations in a velocity-pressure formulation, discretized by centered finite difference schemes, accurate to the second order. The application described is a single vortex that has an initial velocity profile resembling delta wing vortices. Comparisons are made with experimental data and with other simulation methods. Author

A90-34325#
DIFFERENTIAL EQUATION MODELING OF DYNAMIC STALL
D. PETOT (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 5, 1989, p. 59-72. refs
Copyright

This study concerns dynamic stall in a two-dimensional flow, and more precisely the modeling of the global aerodynamic forces by means of differential equations derived from wind tunnel tests. The equations were arrived by measuring the aerodynamic coefficients on an airfoil subjected to low-amplitude vibrations. When the model took its final form, it was possible to calculate its parameters directly from large-amplitude measurements. The formula proposed here finds the lift, moment, and drag for pitching and heaving actions and for a wind-speed variation, and has been verified by wind-tunnel tests whenever possible. Author

A90-34356
A TECHNIQUE FOR CALCULATING NONLINEAR NORMAL-FORCE AND PITCHING-MOMENT COEFFICIENTS FOR SLENDER DELTA WINGS, ACCOUNTING FOR WING THICKNESS [EIN VERFAHREN ZUR BERECHNUNG NICHTLINEARER NORMALKRAFT- UND KIPPMOMENTENBEIWERTE AN SCHLANKEN DELTAFLUEGELN UNTER BERUECKSICHTIGUNG DER FLUEGELDICKE]
D. NIKOLITSCH (MBB GmbH, Munich, Federal Republic of Germany) and CH. M. GABRIEL Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 14, no. 1-2, 1990, p. 67-75. In German.
Copyright

A numerical procedure for estimating the vortex and source distributions on a slender delta wing in inviscid incompressible flow is developed analytically and demonstrated. In this approach, it is assumed that the free vortices are shed from the wing at an angle equal to 0.7 times the angle of attack, and the integral coefficients of normal force and pitching moment are derived from the vortex distribution. Details of the discretization of the integral equation for the vortex density are discussed; the procedure for incorporating the effects of wing thickness is outlined; and numerical results are presented in extensive graphs and shown to be in good agreement with the experimental data of Hummel (1967). The possible extension of the method to rectangular and trapezoidal wings is briefly considered. T.K.

A90-34380* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPUTATIONAL AEROTHERMODYNAMICS
GEORGE S. DEIWERT (NASA, Ames Research Center, Moffett Field, CA) IN: Supercomputing '89; Proceedings of the Second Conference, Reno, NV, Nov. 13-17, 1989. Washington, DC/New York, IEEE Computer Society/ACM Press, 1989, p. 51-57. refs
Copyright

Computational aerothermodynamics concerns the coupling of real gas effects with equations of motion to include thermochemical rate processes for chemical and energy exchange phenomena. These processes concern the creation and destruction of gas species by chemical reactions and the transfer of energy between the various species and between the various energy modes (e.g., translation, rotation, vibration, ionization, dissociation/recombination, etc.) of the species. To gain some insight into when such phenomena occur for current and future aerospace flight vehicles the author shows the flight regimes of some typical vehicles (e.g., Concord, aerospace plane, Space Shuttle, associated space transfer vehicles, Apollo entry vehicle, etc.) in terms of flight altitude and flight speed. Also indicated are regimes where chemical reactions such as dissociation and ionization are important and where nonequilibrium thermochemical phenomena are important. I.E.

A90-34545* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HIGH-RESOLUTION SHOCK-CAPTURING SCHEMES FOR INVISCID AND VISCOUS HYPERSONIC FLOWS
H. C. YEE (NASA, Ames Research Center, Moffett Field, CA), G. H. KLOPFER (Nielsen Engineering and Research, Inc., Mountain View, CA), and J.-L. MONTAGNE (ONERA, Chatillon, France) Journal of Computational Physics (ISSN 0021-9991), vol. 88, May 1990, p. 31-61. refs
Copyright

Hypersonic computations are presently conducted with an extension of a class of high-resolution implicit TVD algorithms suited to transonic multidimensional Euler and Navier-Stokes equations. These conservative shock-capturing schemes, which are spatially second- and third-order, may be first- and second-order accurate in time and suitable for either steady or unsteady calculations. Attention is given to the enhancement of hypersonic flows' convergence rate and stability; accuracy and efficiency is achieved by these means for very complex two-dimensional hypersonic viscous and inviscid shock interactions. O.C.

A90-34583
PARTICULATE TRAJECTORIES AND IMPACT CHARACTERISTICS IN HYPERSONIC FLIGHT INVOLVING GAS COOLANT SHIELDING
GREG W. BURGREEN (Teledyne Brown Engineering, Huntsville, AL) IN: Window and dome technologies and materials; Proceedings of the Meeting, Orlando, FL, Mar. 27-29, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 352-358. refs
(Contract DASG60-87-C-0042)
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A simple numerical method has been developed to predict the trajectories and impact characteristics of solid particulate material after traversal of the complex flow structure existing over a hypersonic forebody. Specifically, particle impact characteristics are examined for an aerodynamic structure incorporating a forebody window assembly which is shielded from aerodynamic heating via gas coolant flow. For calculation of the flow field properties inside the shock layer surrounding the forebody, a computational fluid dynamics (CFD) numerical solution of the hypersonic compressible flow field is employed. The nature of the aerodynamic drag acting on the particle is thoroughly investigated. Author

A90-34672
A NUMERICAL METHOD FOR CALCULATING SUPERSONIC FLOWS OF A VISCOUS GAS [CHISLENNYI METOD RASCHETA SVERKHZVUKOVYKH TECHENII VIAZKOGO GAZA]
S. G. KARATAEV and V. N. KOTEROV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 30,

April 1990, p. 586-600. In Russian. refs
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A numerical method for calculating simplified stationary Navier-Stokes equations is proposed which employs the variables 'current function-orthogonal complement'. For solving a system of difference equations, a modified version of the global iteration method is proposed which significantly accelerates the convergence of the iteration process. Examples of calculations are presented, and the results are compared with the results of the asymptotic theory of local separated flows. V.L.

A90-34674
AN IMPLICIT SCHEME WITH FLOW CORRECTION FOR THE NUMERICAL SOLUTION OF THE EULER EQUATION [O NEIAVNOI SKHEME S KORREKTSIEI POTOKOV DLIA CHISLENNOGO RESHENIIA URAVNENII EILERA]
V. I. PINCHUKOV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 30, April 1990, p. 626-628. In Russian. refs
Copyright

An approach to solving the Euler equation is proposed which is based on the use of a monotonic scheme with a structure similar to that proposed in an earlier study (Pinchuk, 1983). To demonstrate the approach, pressure distributions are calculated for airfoils at angle of attack in flows with Mach 0.75 and 0.80. It is shown that the approach proposed here provides an adequate description of flows with complex discontinuity structures. V.L.

A90-34817#
ON A LIFTING LINE THEORY FOR SUPERSONIC FLOW. II - A SUPERSONIC LIFTING LINE THEORY FOR WINGS
V. N. CONSTANTINESCU (Institutul Politehnic, Bucharest, Rumania) and I. JADIC (Institutul National pentru Creatie Stiintifica si Tehnica, Bucharest, Rumania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 34, Nov.-Dec. 1989, p. 553-565. refs

Results on the velocity induced by a vortex line in supersonic flow (Constantinescu and Jadic, 1989) are used to propose a supersonic lifting line theory for wings. To ensure proper agreement with two-dimensional supersonic flow theory for wings of large aspect ratio, a constant distribution of bound vortices is assumed along the chord. The position of the control point is determined by imposing agreement in the second limiting situation. It is found that the control point must be placed at the trailing edge. The method, which uses solutions similar to those for subsonic lifting line theory, is tested against several cases of wing data. Possible ways of improving the method's accuracy are discussed. R.B.

A90-34819#
ON AN EXTENSION OF THE KUTTA-JOUKOWSKI THEOREM TO THE SUPERSONIC REGIME
I. JADIC (Institutul National pentru Creatie Stiintifica si Tehnica, Bucharest, Rumania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 34, Nov.-Dec. 1989, p. 603-609.

The Kutta-Joukowski theorem for subsonic flows is extended to produce a formula for the direct calculation of the force generated upon an infinite vortex line by a uniform supersonic flow. In the case of a finite strength vortex line, the induced velocity tends to infinity in the wave front, while tending to zero elsewhere. It is found that formulas can only account for vortex lines of infinitely small strength. R.B.

A90-34821#
A VERIFICATION OF THE SUPERSONIC LIFTING LINE THEORY FOR THE CASE OF INFINITE YAWED WINGS
I. JADIC (Institutul National pentru Creatie Stiintifica si Tehnica, Bucharest, Rumania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 35, Jan.-Feb. 1990, p. 17-32. refs

A verification of the supersonic lifting line type (SLLT) method is carried out for the limiting case of large-aspect-ratio two-dimensional yawed wings. The result for such wings with supersonic edges is that SLLT gives the correct limit regardless of the position of the control point. For two-dimensional yawed wings with subsonic edges, the theoretical distribution along the chord takes the usual subsonic form: infinite at the leading edge and zero at the trailing edge. The control point must be chosen at approximately 88 percent of the chord for SLLT to agree with the correct theoretical results. S.A.V.

A90-34864
SHOCK-FITTING METHOD FOR TWO-DIMENSIONAL INVISCID, STEADY SUPERSONIC FLOWS IN DUCTS
ROBERTO MARSILIO (Torino, Politecnico, Turin, Italy) and GINO MORETTI (GMAF, Inc., Freeport, NY) Meccanica (ISSN 0025-6455), vol. 24, Dec. 1989, p. 216-222. refs
Copyright

A numerical technique to solve the Euler equations for two-dimensional, steady, inviscid, supersonic flows in ducts is presented. The technique is second-order accurate and is based on the lambda-scheme plus shock-fitting method. Many cases have been tested. The method used and the results obtained demonstrate the versatility of the technique specially if confronted with analogous methods that use shock-capturing techniques.
Author

N90-20044 Stanford Univ., CA.
COMPUTATION OF HYPERSONIC LOW DENSITY FLOWS WITH THERMOCHEMICAL NONEQUILIBRIUM Ph.D. Thesis
TAHIR GOEKCEN 1989 128 p
Avail: Univ. Microfilms Order No. DA8925870

Recent interest in hypersonic transitional flows, transitional referring to the flow regime between continuum, and free-molecular flows, is motivated by the current and projected flight activities at high altitudes and at high speeds. A new thermochemical nonequilibrium formulation appropriate to hypersonic transitional flows of air was developed. The present nonequilibrium gas model for air consists of five chemical species: diatomic species; molecular nitrogen N2, molecular oxygen O2, nitric oxide NO, and atomic species; atomic nitrogen N and atomic oxygen O. The local thermodynamic state of the gas is described by three temperatures corresponding to three internal energy modes, i.e., translational temperature T, vibrational temperature T (sub v), and rotational temperature T (sub r). The thermal and chemical nonequilibrium processes are vibrational and rotational relaxation for the diatomic species and chemical reactions among the five chemical species. Slip and catalytic wall boundary conditions are included in the formulation. The governing partial differential equations with the proper boundary conditions are solved numerically using an implicit time marching finite volume technique. The computed results are compared with the existing Monte Carlo simulations in terms of surface quantities such as drag and heat transfer and in terms of nonequilibrium flow structure. Dissert. Abstr.

N90-20046*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL AND THEORETICAL AERODYNAMIC CHARACTERISTICS OF A HIGH-LIFT SEMISPAN WING MODEL
ZACHARY T. APPLIN and GARL L. GENTRY, JR. Washington May 1990 111 p
(NASA-TP-2990; L-16441; NAS 1.60:2990) Avail: NTIS HC A06/MF A01 CSCL 01A

Experimental and theoretical aerodynamic characteristics were compared for a high-lift, semispan wing configuration that incorporated a slightly modified version of the NASA Advanced Laminar Flow Control airfoil section. The experimental investigation was conducted in the Langley 14- by 22-Foot Subsonic Tunnel at chord Reynolds numbers of 2.36 and 3.33 million. A two-dimensional airfoil code and a three-dimensional panel code were used to obtain aerodynamic predictions. Two-dimensional data were corrected for three-dimensional effects. Comparisons between predicted and measured values were made for the cruise configuration and for various high-lift configurations. Both codes predicted lift and pitching moment coefficients that agreed well

with experiment for the cruise configuration. These parameters were overpredicted for all high-lift configurations. Drag coefficient was underpredicted for all cases. Corrected two-dimensional pressure distributions typically agreed well with experiment, while the panel code overpredicted the leading-edge suction peak on the wing. One important feature missing from both of these codes was a capability for separated flow analysis. The major cause of disparity between the measured data and predictions presented herein was attributed to separated flow conditions. Author

N90-20047*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
USING TRANSONIC SMALL DISTURBANCE THEORY FOR PREDICTING THE AEROELASTIC STABILITY OF A FLEXIBLE WIND-TUNNEL MODEL
WALTER A. SILVA (Lockheed Engineering and Sciences Co., Hampton, VA.) and ROBERT M. BENNETT Mar. 1990 13 p Presented at the AIAA 31st Structures, Structural Dynamics, and Materials Conference, Long Beach, CA, 2-4 Apr. 1990
(NASA-TM-102617; NAS 1.15:102617) Avail: NTIS HC A03/MF A01 CSCL 01A

The CAP-TSD (Computational Aeroelasticity Program - Transonic Small Disturbance) code, developed at the NASA - Langley Research Center, is applied to the Active Flexible Wing (AFW) wind tunnel model for prediction of the model's transonic aeroelastic behavior. Static aeroelastic solutions using CAP-TSD are computed. Dynamic (flutter) analyses are then performed as perturbations about the static aeroelastic deformations of the AFW. The accuracy of the static aeroelastic procedure is investigated by comparing analytical results to those from previous AFW wind tunnel experiments. Dynamic results are presented in the form of root loci at different Mach numbers for a heavy gas and air. The resultant flutter boundaries for both gases are also presented. The effects of viscous damping and angle-of-attack, on the flutter boundary in air, are presented as well. Author

N90-20048# Boston Univ., MA.
UNSTEADY FREE-WAKE VISCOUS AERODYNAMIC ANALYSIS OF HELICOPTER ROTORS Final Report, 9 Feb. 1987 - 8 Oct. 1989
LUIGI MORINO, SLOBODAN SIPCIC, and MARK DOWNEY Nov. 1989 24 p
(Contract DAAL03-87-K-0022; ARO PROJ. P-24025-EG)
(AD-A217166; ARO-24025.12-EG) Avail: NTIS HC A03/MF A01 CSCL 01/1

This report contains the results for research on unsteady free-wake viscous aerodynamic analysis of helicopter rotors. The effort may be divided into three general areas. The first deals with further developments of the zeroth-order potential-flow analysis; the second with the first-order analysis; and the third with the Poincare decomposition for the analysis of viscous flows. GRA

N90-20050*# Institute for Computer Applications in Science and Engineering, Hampton, VA.
SPECTRAL SIMULATION OF UNSTEADY COMPRESSIBLE FLOW PAST A CIRCULAR CYLINDER Final Report
WAI-SUN DON and DAVID GOTTLIEB (Brown Univ., Providence, RI.) Apr. 1990 25 p Submitted for publication
(Contract NAS1-18107; NAS1-18605; NAG1-703; AF-AFOSR-0303-85; NSF DMS-88-10150)
(NASA-CR-182030; NAS 1.26:182030; ICASE-90-29) Avail: NTIS HC A03/MF A01 CSCL 01/1

An unsteady compressible viscous wake flow past a circular cylinder was successfully simulated using spectral methods. A new approach in using the Chebyshev collocation method for periodic problems is introduced. It was further proved that the eigenvalues associated with the differentiation matrix are purely imaginary, reflecting the periodicity of the problem. It was been shown that the solution of a model problem has exponential growth in time if improper boundary conditions are used. A characteristic boundary condition, which is based on the characteristics of the Euler equations of gas dynamics, was derived for the spectral code. The primary vortex shedding frequency computed agrees well with the results in the literature for Mach = 0.4, Re = 80. No secondary frequency is observed in the power spectrum analysis of the pressure data. Author

N90-20051*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NUMERICAL SIMULATIONS OF SUPERSONIC FLOW THROUGH OSCILLATING CASCADE SECTIONS
DENNIS L. HUFF and T. S. R. REDDY (Toledo Univ., OH.) 1990 10 p Presented at the 15th Southeastern Conference on Theoretical and Applied Mechanics, Atlanta, GA, 22-23 Mar. 1990; sponsored by Georgia Inst. of Technology
(NASA-TM-103100; E-5421; NAS 1.15:103100) Avail: NTIS HC A02/MF A01 CSCL 01/1

A finite difference code was developed for modeling inviscid, unsteady supersonic flow by solution of the compressible Euler equations. The code uses a deforming grid technique to capture the motion of the airfoils and can model oscillating cascades with any arbitrary interblade phase angle. A flat plate cascade is analyzed, and results are compared with results from a small perturbation theory. The results show very good agreement for both the unsteady pressure distributions and the integrated force predictions. The reason for using the numerical Euler code over a small perturbation theory is the ability to model real airfoils that have thickness and camber. Sample predictions are presented for a cascade of loaded airfoils and show appreciable differences in the unsteady surface pressure distributions when compared with the flat plate results. Author

N90-20052*# Stanford Univ., CA. Dept. of Aeronautics and Astronautics.
TRANSPIRATION COOLING IN HYPERSONIC FLIGHT
DOMINGO TAVELLA and LEONARD ROBERTS Jun. 1989 31 p
(Contract NCC2-543)
(NASA-CR-186435; NAS 1.26:186435; SU-JIAA-TR-92) Avail: NTIS HC A03/MF A01 CSCL 01/1

A preliminary numerical study of transpiration cooling applied to a hypersonic configuration is presented. Air transpiration is applied to the NASA all-body configuration flying at an altitude of 30500 m with a Mach number of 10.3. It was found that the amount of heat disposal by convection is determined primarily by the local geometry of the aircraft for moderate rates of transpiration. This property implies that different areas of the aircraft where transpiration occurs interact weakly with each other. A methodology for quick assessments of the transpiration requirements for a given flight configuration is presented. Author

N90-20053# Computational Mechanics Co., Austin, TX.
ANALYSIS OF FLOW-, THERMAL-, AND STRUCTURAL-INTERACTION OF HYPERSONIC STRUCTURES SUBJECTED TO SEVERE AERODYNAMIC HEATING Annual Technical Report No. 2, 1 Nov. 1988 - 1 Nov. 1989
30 Nov. 1989 109 p
(Contract F49620-88-CK-0001; AF PROJ. 2302)
(AD-A217882; TR-89-15; AFOSR-90-0050TR) Avail: NTIS HC A06/MF A01 CSCL 01/1

Over the past two years a unique collection of algorithms have been developed for the analysis of hypersonic structures subjected to severe aerodynamic heating. These algorithms employ adaptive computational methods to resolve many of the complex structural and flow features such as nonelastic, large, time dependent structural deformations, shock interaction boundary layers and shock interactions. Local error estimates were used to evaluate the quality of the computed solutions and subsequently optimize the structure of the grids to deliver a specified level of accuracy with a minimum of computational effort. In addition, implicit/explicit solution algorithms for the fluid modeling were employed which exploit the speed and simplicity of explicit methods and the stability of implicit methods. Zoning techniques for automatically selecting the implicit and explicit zones were studied with optimization of the computational effort as the central goal.

The modeling of the structural problems incorporated a version of the Bodner-Partom constitutive model for time dependent viscoplastic materials. This model was extended to include a damage parameter which was treated as an additional internal state variable. A number of validation cases were run to test the various components of the package and prepare for the experimental verification which was planned for year three. GRA

N90-20944 North Carolina State Univ., Raleigh.
RELATING FLOW BETWEEN COUNTER-ROTATING PROPELLERS TO AERODYNAMIC INTERACTION NOISE Ph.D. Thesis
HOWARD VAN LIEW PATRICK 1989 199 p
Avail: Univ. Microfilms Order No. DA8918129

Axial and circumferential flow velocity components were measured at discrete points between 28 cm diameter straight bladed, hobby-craft model aircraft counter-rotating propellers using a single sensor hot-film anemometer. Coherence analysis was used to determine a relationship between the far-field radiated noise and the measured flow velocity components at the primary aerodynamic interaction tones. Tests were performed in an open-jet anechoic wind tunnel with a 0.6 m square nozzle at a free-stream speed of 0.08 Mach number. The forward propeller had three blades and the abaft propeller consisted of four blades. Primary test variables were radical and axial positions of the hot-film sensor and rotor-to-rotor spacing. The major conclusions were based upon the concept that if the relationship between the fluid flow velocity and the radiated noise was linear, the coherence function would be expected to be unity. At the primary aerodynamic interaction frequencies, it was determined that the degree of linearity varied radially along the propeller blade span, i.e., nonlinearities were found to exist. This partial linearity was composed of three distinct regions. Near the motor housing, there existed a small region of appreciable linearity, for both flow components, which decreased dramatically a short distance out from the housing. This phenomenon was associated with the viscous boundary layer flow from the motor housing. Dissert. Abstr.

N90-20945 Florida Univ., Gainesville.
ON TOTAL VARIATION DIMINISHING SCHEMES FOR TRANSONIC TURBULENT FLOW COMPUTATION Ph.D. Thesis
MING-HSIUNG CHEN 1988 151 p
Avail: Univ. Microfilms Order No. DA8923945

Recently a number of techniques for constructing nonlinear, second-order accurate, high-resolution shock capturing schemes for systems of hyperbolic conservation laws were developed in order to simulate complex flow fields more accurately and efficiently. These schemes, called total variation diminishing (TVD), are free from generating spurious oscillations across the shocks and contact discontinuities, and can converge to physically realizable solution with the aid of entropy correction. The TVD schemes developed for two-dimensional planar flows were extended to three-dimensional flows. On the application side, a thin-layer Navier-Stokes flow code based on the conventional Beam-Warming scheme was modified to incorporate the TVD schemes in the solution process. A variable time step procedure was also implemented into the code for more efficient computation of the steady state flows. The transonic turbulent flow over an axisymmetric projectile is adopted as the test problem to assess the performance of three variants of the TVD scheme, two upwind schemes with flux limiters proposed by Van Leer and Roe and one symmetric scheme. The combinations of the high accuracy, good robustness, and improving computational efficiency offered by the TVD schemes make them extremely attractive for computing flow with shocks. Among the three variants, it is found that the convergence rate of the flux limiter proposed by Van Leer for the upwind TVD scheme is least affected by the incoming flow Mach numbers. Dissert. Abstr.

N90-20947 North Carolina State Univ., Raleigh.
AN APPROXIMATE VISCOUS SHOCK LAYER METHOD FOR CALCULATING THE HYPERSONIC FLOW OVER BLUNT-NOSED BODIES Ph.D. Thesis
ARTHUR CHRISTIAN GRANTZ 1989 154 p
Avail: Univ. Microfilms Order No. DA8926329

An approximate method is presented which can calculate the surface and flow-field properties for the fully viscous hypersonic flow over blunt-nosed bodies at an angle of attack. Using the second order pressure equation of Maslen and incorporating viscous terms into the streamwise momentum and energy equations, a simple method is obtained which can calculate both the subsonic and supersonic regions of the shock layer and does not require a starting solution for the shock shape. Surface heat transfer and pressure predictions from the present method compare very well with the more accurate viscous shock layer method, flight and wind tunnel data at zero degrees angle of attack. Equilibrium air and turbulence models are also incorporated into the approximate method. Surface pressure results compare well with theory and experiment for 15 and 25 degree sphere cones, at small to moderate angles of attack. Comparisons with experiment and a viscous shock layer method indicate that the approximate method does not calculate surface streamlines accurately, however. Consequently, surface heat transfer rate predictions which are accurate for small angles of attack, deteriorate for larger angles of attack where the calculated surface streamlines are less accurate. Surface pressures are well predicted since the accuracy of surface streamlines has only a small effect on the pressure. Dissert. Abstr.

N90-20948# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
COMPARISON OF C- AND O-GRID GENERATION METHODS USING A NACA 0012 AIRFOIL M.S. Thesis
MARK J. LUTTON Dec. 1989 128 p
(AD-A216375; AFIT/GAE/ENY/89D-21) Avail: NTIS HC A07/MF A01 CSCL 20/4

An investigation is undertaken to compare the performance of C- and O-grid generation methods as applied to numerically predicting the flow about a NACA 0012 airfoil. Both types of grid were generated using a hyperbolic grid generation code. The solution of the flow field was numerically calculated using the Beam and Warming algorithm to solve the two-dimensional Navier-Stokes equations for viscous, compressible flow. Numerical solutions are obtained for Mach number ranging from 0.3 to 1.1, angle of attack ranging from 0 to 13 degress, and Reynolds numbers between 2 and 6 million. The numerical results obtained from both C- and O-grids are compared to experimental data. Results indicate a weakness is the method of applying the boundary conditions in the wake or the C-grid, while the overall resolution in the wake is poor for the O-grid due to inadequate control of grid spacing in that region. The transformation metrics are examined to explain differences observed in grid performance. GRA

N90-20950*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics.
EFFECTS OF NOSE BLUNTNESS AND SHOCK-SHOCK INTERACTIONS ON BLUNT BODIES IN VISCOUS HYPERSONIC FLOWS Progress Report, period ending 31 Dec. 1989
D. J. SINGH and S. N. TIWARI Jan. 1990 187 p
(Contract NAG1-423)
(NASA-CR-186451; NAS 1.26:186451) Avail: NTIS HC A09/MF A01 CSCL 01/1

A numerical study was conducted to investigate the effects of blunt leading edges on the viscous flow field around a hypersonic vehicle such as the proposed National Aero-Space Plane. Attention is focused on two specific regions of the flow field. In the first region, effects of nose bluntness on the forebody flow field are investigated. The second region of the flow considered is around the leading edges of the scramjet inlet. In this region, the interaction of the forebody shock with the shock produced by the blunt leading edges of the inlet compression surfaces is analyzed. Analysis of these flow regions is required to accurately predict the overall flow field as well as to get necessary information on localized

zones of high pressure and intense heating. The results for the forebody flow field are discussed first, followed by the results for the shock interaction in the inlet leading edge region. Author

N90-20951# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.
MULTIGRID ACCELERATED RELAXATION SOLUTION OF TRANSONIC FULL POTENTIAL FLOW EQUATION
J. P. SINGH Dec. 1989 30 p
(PD-CF-8942) Avail: NTIS HC A03/MF A01

The multigrid method has been incorporated in the Garabedian-Korn inviscid code, as adapted at N.A.L., to accelerate its convergence. The results show a large CPU time saving in achieving converged solution with a residue tolerance level of 10(exp -4). The demonstrations include both subcritical and supercritical Mach numbers. Author

N90-20952*# Cessna Aircraft Co., Wichita, KS.
FLIGHT TEST INVESTIGATION OF CERTIFICATION ISSUES PERTAINING TO GENERAL-AVIATION-TYPE AIRCRAFT WITH NATURAL LAMINAR FLOW
WAYNE A. DOTY Apr. 1990 49 p
(Contract NAS1-18561)
(NASA-CR-181967; NAS 1.26:181967) Avail: NTIS HC A03/MF A01 CSCL 01/1

Development of Natural Laminar Flow (NLF) technology for application to general aviation-type aircraft has raised some question as to the adequacy of FAR Part 23 for certification of aircraft with significant NLF. A series of flight tests were conducted with a modified Cessna T210R to allow quantitative comparison of the aircraft's ability to meet certification requirements with significant NLF and with boundary layer transition fixed near the leading edge. There were no significant differences between the two conditions except an increasing in drag, which resulted in longer takeoff distances and reduced climb performance. Author

N90-20954 Texas Univ., Austin.
COMPUTATION OF NONEQUILIBRIUM CHEMICALLY REACTING FLOWS IN HYPERSONIC FLOW FIELD Ph.D. Thesis
TING-LUNG CHIANG 1989 186 p
Avail: Univ. Microfilms Order No. DA8920677

In recent years a renewed interest in the design of various hypersonic vehicles has necessitated the inclusion of chemically reacting flows for the solution of hypersonic flowfields. From the physical point of view, all chemical reactions take some time to reach equilibrium state. Therefore, finite-rate (nonequilibrium) chemistry models must be utilized for hypersonic flowfield computations. A compelling difficulty in the numerical simulation of chemically reacting flow is the selection of the marching time step. Usually, the characteristic time scale of the gas dynamic equations is different from that of the chemistry equations. A numerical algorithm that determines the chemistry marching time step is developed. Von Neumann stability analysis is applied to the chemistry equations to provide a criteria for the selection of time step for a stable solution. Both the quasi one-dimensional nozzle problem and the 2-D/axisymmetric blunt body problem are used for numerical validation. Unsteady Euler equations and chemistry equations are written in the conservative form so that the shock capturing scheme can be applied. A five species model is selected for the air compositions. The governing equations are discretized by an implicit, flux-splitting finite difference formulation to provide a better stability characteristic and faster convergence. The gas dynamic equations and chemistry equations are solved interactively and communicated by the loosely-coupled scheme. Author

N90-20955 Purdue Univ., West Lafayette, IN.
A TWO-DIMENSIONAL UNSTEADY ANALYSIS FOR TRANSONIC AND SUPERSONIC CASCADE FLOWS Ph.D. Thesis
YUNG-FU KAO 1989 162 p
Avail: Univ. Microfilms Order No. DA9003914

A mathematical model based on the 2-D unsteady full potential equation was developed to predict the unsteady response of cascade flows at subsonic, transonic, and supersonic speeds. A time marching algorithm based on a quasi-Newton iteration technique is employed. A time sheared scheme is used to calculate non-Zero interblade phase angle oscillation cases. Multiple passage calculations are needed if the interblade time lag is large. Contrary to the classical linear theory, the effects of blade shape, flow incidence angle, cascade geometries, and presence of shock wave are fully considered. The validity and accuracy was demonstrated by comparison to available experimental data and other theoretical analyses over wide flow ranges for various cascade configurations. The mathematical model and procedures adopted can be applied to turbomachinery flutter analysis. Dissert. Abstr.

N90-20956 Purdue Univ., West Lafayette, IN.
MEASUREMENT OF LIFT DEVELOPMENT ON RAPIDLY-ACCELERATED WINGS Ph.D. Thesis
RICHARD STEVEN SAWYER 1989 198 p
Avail: Univ. Microfilms Order No. DA9003954

Current analyses for treating the response of wings in unsteady flow fields are either extremely costly or involve major simplifications to allow calculation. Such simplifications normally include neglecting the effects of viscosity and assuming a simple wake model. Situations are explored wheresuch analyses were expected to fail, as well as work. For one set of tests, a large bore, short stroke air cylinder was used to give models a rapid acceleration to a constant speed. Other tests were performed using models under constant accelerations from rest. Lift as a function of time for various planforms was gathered using combinations of piezoelectric force tranducers. The result of the Fast Start test was that the analytical indicial response function, derived for a finite wing, does manifest itself in a real test. Constant Acceleration tests furnished numerous conclusions. Response of a rectangular wing was much higher than expected, due to a finite development time for a laminar separation. Delta wing studies showed lower response than expected for pre-stall tests, possibly as a result of leading edge vortex burst movement under acceleration. Post-stall delta wing tests featured a nonmonotonic response with acceleration. This was attributed to a reformation or destruction of large scale structures in an otherwise bluff body wake. Dissert. Abstr.

N90-20957 California Univ., Davis.
CONVERGENCE ACCELERATION OF HYPERSONIC FLOW CALCULATIONS: A NONLINEAR RELAXATION FACTOR Ph.D. Thesis
SAMSON HOK-CHI CHEUNG 1989 120 p
Avail: Univ. Microfilms Order No. DA9002725

In computational fluid dynamics (CFD), steady-flow solutions are typically obtained from computer codes in which a large number of iterations are performed. The iterations are required to evolve the solution from initial conditions. In order to capture meaningful physical features of the flow field, such as boundary layers, separation points, and vortices in two or three-dimensional problems, very fine grids are needed. Also, it was noticed that a code which runs fast in subsonic and transonic flow simulations is not necessarily fast in hypersonic simulations. Thus, in order to resolve any of these realistic features, a large amount of computer time (CPU time) is required. The objective is to speed up the rates of convergence for hypersonic flow calculations and explore the underlining mathematical theory. The rates of convergence of viscous and inviscid hypersonic flow calculations computed using the Steger-Warming flux vector splitting scheme are analyzed and accelerated. Techniques such as Wynn's epsilon-algorithm and overrelaxation methods are applied to accelerate the rate of convergence. A relaxation factor for the nonlinear iterative scheme is found analytically and confirmed numerically. The effect of the relaxation factor on the spectrum of the iterative matrix is studied. It is shown that such an overrelaxation factor produces a favorable preconditioning for Wynn's epsilon-algorithm. A net savings of 40 to 60 percent in computer time is demonstrated for many cases in two and three-dimensional calculations. Author

N90-20958 Iowa Univ., Iowa City.
COMPUTATION OF VISCOUS FLOW AROUND A PROPELLER-SHAFT CONFIGURATION WITH INFINITE-PITCH RECTANGULAR BLADES Ph.D. Thesis
HYOUNG-TAE KIM 1989 278 p
Avail: Univ. Microfilms Order No. DA9004919

A viscous-solution method is set forth for calculating marine propeller flow fields. The overall computational method is described, and results for both laminar and turbulent flow are presented and discussed with regard to the flow physics, for the idealized geometry of a propeller-shaft configuration with infinite pitch rectangular blades. It is shown that the flow exhibits many of the distinctive features of interest, including the development and evolution of the shaft and blade boundary layers and wakes, and tip, passage, and hub vortices. Also considered are the influences of a thick-inlet boundary layer, the propeller angular velocity, and the blade number. Comparisons are made with some relevant experimental and computational studies, including results from a lifting-surface propeller-performance program, to aid in evaluating the present method. Close similarity and consistency are demonstrated. The latter case shows that the present method accurately predicts the blade loading, including viscous effects, and clearly displays the ability to resolve the viscous regions in distinction from the inviscid flow approach. Dissert. Abstr.

N90-20959 Council for National Academic Awards (England).
FLOW IN A FORWARD SWEPT CENTRIFUGAL FAN, VOLUMES 1 AND 2 Ph.D. Thesis
B. E. MEALING 1988 583 p
Avail: Univ. Microfilms Order No. BRDX86775

The original objective, to improve the efficiency of a forward curved centrifugal fan, was redirected to the urgent solution of a serious impeller life problem arising under certain service conditions. Using a variety of techniques, the flow pattern within the blade passage was analyzed and the cause of the problem diagnosed. A new impeller was designed and was found to solve the service life problem while also yielding an improvement in efficiency. Because the project was carried out under the Total Technology program, the scope was widened to include consideration of the fan application in a suction roadsweeper: as a result of the wider technical and commercial study, an opportunity was identified for a new product offering benefits much greater than those sought within the scope of the original objective.
Dissert. Abstr.

N90-20960 Rensselaer Polytechnic Inst., Troy, NY.
OPTIMUM HYPERSONIC AIRFOILS WITH ATTACHED SHOCKS Ph.D. Thesis
BARBARA AGNES WAGNER 1989 112 p
Avail: Univ. Microfilms Order No. DA9011319

In the framework of Hypersonic Small Disturbance Theory the self-similar flow generated by power law bodies F(x) = x sup k is studied. A body shape which is optimum with respect to (C (sup 3/2) sub L)(C sub D) is found. Furthermore a wider class of shapes is constructed using the streamlines of the known flow field and an optimum is found within this wider class. Use is made of the solution of this problem for a generalization of Nonweiler's idea leading to the design of the caret wing and here leading to the design of a wide class of 3-D hypersonic wings. Also Cole and Aroesty's solution for the flow field of a class of bodies supporting exponential shock shapes is used to design 3-D wings. Finally, a 3-D perturbation of the basic caret wing is formulated and solved. Here, the off-design condition consists of a small deviation of the cross section shape from the inverted V cross section shape.
Dissert. Abstr.

N90-20961 Southampton Univ. (England).
MEASUREMENT AND PREDICTION OF PROPELLER BLADE SURFACE PRESSURE DISTRIBUTIONS Ph.D. Thesis
DAVID TUDOR OWEN 1989 202 p
Avail: Univ. Microfilms Order No. BRDX87364

The development of an advanced method for the aerodynamic testing of model propellers is described. The technique involves the measurement of the time averaged surface pressure distributions on rotating model propeller blades, thereby giving access to more detailed information than was previously possible. This information may be used both to improve the fundamental understanding of propeller aerodynamics, and to provide high quality detailed validation data for theoretical predictive techniques. The experimental system is described, and results showing the effects of changes in advance ratio, blade setting angle, number of blades, and nacelle geometry are discussed. Flow phenomena unrepresentative of full scale flight conditions were identified and removed, thus ensuring the realistic testing of propellers at model scale. In addition, the development of a potential flow theoretical method for the prediction of the flowfield around propeller/axisymmetric nacelle combinations is described. The technique uses a vortex lattice representation for the propeller blades, together with a surface source distribution for the non-lifting surfaces (spinner, hub, and nacelle). The method is found to predict all the trends experimentally observed and to give good numerical agreement for the blade surface pressures over the outboard half of the propeller radius. Author

N90-20963# Helsinki Univ. of Technology, Espoo (Finland). Lab. of Aerodynamics.
AN EVALUATION OF THE TWO-DIMENSIONAL EULER AND NAVIER-STOKES CALCULATIONS BASED ON A FLUX-VECTOR SPLITTING
TIMO SIIKONEN and JAAKKO HOFFREN 28 Sep. 1989 38 p
(PB90-166778; SER-B-89-B18; ISBN-951-22-0040-6; ISSN-0358-2620) Avail: NTIS HC A03/MF A01 CSCL 01/1

A method involving a flux vector splitting with a multigrid acceleration for the solution of the Euler equations, and for the solution of the thin-layer Navier-Stokes equations was applied. The performance of the Euler thin-layer Navier-Stokes code is evaluated. Emphasis is laid on the accuracy of the calculated force coefficients, as well as on the computational efficiency with different computers. Computational results are presented for inviscid and viscous flows over a NACA 0012 airfoil. Author

N90-20964# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
EXPERIMENTAL AND NUMERICAL INVESTIGATION OF THE VORTEX FLOW OVER A SHARP EDGED DELTA WING; WITH AND WITHOUT SIDESLIP
S. H. J. NAARDING and N. G. VERHAAGEN Dec. 1988 227 p
(PB90-167131; LR-573) Avail: NTIS HC A11/MF A02 CSCL 01/1

Wind tunnel experiments were performed on a sharp edged biconvex delta wing of unit aspect ratio, with and without sideslip. Laserlight sheet and oil flow visualization, as well as total pressure traverses served to establish the evolution of the primary and secondary vortex systems with sideslip. In addition, surface pressure distribution and force balance measurements were performed. Author

N90-20965*# Missouri Univ., Rolla. Dept. of Mechanical Engineering and Aerospace Engineering and Engineering Mechanics.
AN AERODYNAMIC TRADEOFF STUDY OF THE SCISSOR WING CONFIGURATION Final Report
BRUCE P. SELBERG, KAMRAN ROKHSAZ, and CLINTON S. HOUSH May 1990 63 p
(Contract NAG1-975)
(NASA-CR-186576; NAS 1.26:186576) Avail: NTIS HC A04/MF A01 CSCL 01/1

A scissor wing configuration, consisting of two independently sweeping wings was numerically studied. This configuration was also compared with an equivalent fixed wing baseline. Aerodynamic and stability and control characteristics of these geometries were investigated over a wide range of flight Mach numbers. It is demonstrated that in the purely subsonic flight regime, the scissor wing can achieve higher aerodynamic efficiency as the result of slightly higher aspect ratio. In the transonic regime, the lift to drag ratio of the scissor wing is shown to be higher than that of

the baseline, for higer values of the lift coefficient. This tends to make the scissor wing more efficient during transonic cruise at high altitudes as well as during air combat at all altitudes. In supersonic flight, where the wings are maintained at maximum sweep angle, the scissor wing is shown to have a decided advantage in terms of reduced wave drag. From the view point of stability and control, the scissor wing is shown to have distinct advantages. It is shown that this geometry can maintain a constant static margin in supersonic as well as subsonic flight, by proper sweep scheduling. Furthermore, it is demonstrated that addition of wing mounted elevons can greatly enhance control authority in pitch and roll. Author

N90-20977# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Inst. for Theoretical Fluid Mechanics.

PROGRESS IN INVERSE DESIGN AND OPTIMIZATION IN AERODYNAMICS

HELMUT SOBIECZKY *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 10 p Mar. 1990 Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Aerodynamic design was developed to an advanced state of the art: inverse methods allow for strong control of aerodynamic airfoil or wing performance so that optimization strategies are no longer beyond practical use and knowledge bases can be established for the implementation in aerodynamic expert systems. Some recent steps into this direction are reviewed. Author

N90-21013# Centre National de la Recherche Scientifique, Ecully (France).

PARABOLIZED CALCULATIONS OF TURBULENT THREE DIMENSIONAL FLOWS IN A TURBINE DUCT

P. FERRAND, F. LEBOEUF, F. POMMEL, and E. PARKINSON *In* AGARD, Secondary Flows in Turbomachines 9 p Feb. 1990 Sponsored by Direction des Recherches et Etudes Techniques, France

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For a number of practical flows with a dominating convective direction, it is often possible to neglect the diffusive phenomenona in this direction. This hypothesis is particularly true in turbomachinery ducts where the Reynolds numbers are usually very high. In this case, the diffusive terms in the main convective direction are eliminated. Concerning the velocity, the problem described by the Navier-Stokes equations becomes parabolic. However, in all the subsonic zones, the pressure tends to transfer the downstream information in the upstream direction, which is typical of an elliptical behavior. As a consequence, eliminating those diffusive terms in the Navier-Stokes equations is not sufficient to obtain a pure problem. The momentum equations have a parabolic nature and can be treated by a space marching resolution. On the opposite, the elliptic nature of the pressure equation has to be taken into account. In a subsonic flow, with highly curved ducts, it is then necessary to define an hybrid parabolic-elliptical method called quasi-elliptical. The idea, based on parabolized methods recognizing the elliptical pressure effect, was already used successfully by Kulisa-Belloir for local reverse flows. In this case, a boundary-layer model is used in strong interaction with a pressure calculation based on a small potential perturbation method generated by the viscous wall flow. The integral equation obtained with Green's theorem restores properly the elliptical effect on the wall, if the elliptical pressure is to be restored in a supersonic boundary-layer. A new method calculating three dimensional flows in turbomachinery ducts with a quasi-ellipticity hypothesis for the velocity field is presented. The main ideas of the method are presented; then its specific aspects are detailed. At last, its capacity is viewed on a representative test case typical of a turbine duct. Author

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A90-31703#

THE IMPORTANCE OF MEASURED DATA AS A CONTRIBUTION TO REDUCING CREW CAUSED ACCIDENTS

P. L. GALLIMORE (Boeing Commercial Airplanes, Seattle, WA) IN: AIAA/ADPA/NSIA National Total Quality Management Symposium, 1st, Denver, CO, Nov. 1-3, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 167-170.

(AIAA PAPER 89-3219) Copyright

Digital flight data recorders provide the technology necessary for measurement and collection of the parameters essential to understanding operational performance. A need exists to convince various branches of the industry that flight data recording, as an approach to reducing crew-caused accidents, would be an advantage to the crew, the traveling public, and the operator. The practical application of this concept is described. R.E.P.

A90-32304*# National Oceanic and Atmospheric Administration, Norman, OK.

MULTISTROKE CLOUD-TO-GROUND STRIKE TO THE NASA F-106B AIRPLANE

VLADISLAV MAZUR (NOAA, National Severe Storms Laboratory, Norman, OK), BRUCE D. FISHER, and PHILIP W. BROWN (NASA, Langley Research Center, Hampton, VA) Journal of Geophysical Research (ISSN 0148-0227), vol. 95, April 20, 1990, p. 5471-5484. Research supported by NASA. refs

An analysis of electromagnetic waveform records and video images of a multistroke cloud-to-ground (CG) strike to the NASA F-106B instrumented airplane is presented. The CG flash started as a lightning strike triggered by the airplane and later produced multiple return strokes to the ground (the ground strike network registered six return strokes). Although there are some uncertainties in data interpretation resulting from lack of independent measurements with other than the airborne instruments, recoil streamers and eight sequences of dart leaders followed by return strokes (two more than were indicated by the ground network) were identified in the airborne data. At least three of the subsequent return strokes were attached to the airplane. The analysis provides evidence that formation of recoil streamers and dart leaders is accompanied by a surge in continuous current. This feature is similar to that observed in the bidirectional leader development during lightning initiation on the airplane. Author

A90-33710#

AIRCRAFT CABIN INTERIOR SYSTEMS MEETING NEW FAA REGULATIONS

D. A. NOLLEN (Du Pont Fibers and Composites Development Center, Wilmington, DE) IN: Designing with advanced composites; Report on the European Core Conference, 1st, Zurich, Switzerland, Oct. 20, 21, 1988, Conference Papers. Wilmington, DE, DuPont Nomex, 1988, 16 p. refs

The FAA has issued new regulations which enhance the fireworthiness of commercial aircraft interiors. Starting in August of this year, large interior panels will have to meet specified rates of heat release as measured by the Ohio State University Heat Release Calorimeter. The intent of this regulation is to delay the spread of fire in a post-crash scenario allowing passengers more egress time before the nonsurvivable flash-over occurs. This paper describes the flammability performance of honeycomb sandwich panels. Typical interior panels are studied by varying individual components to develop their heat release contributions. It is shown that resin content and type, declam, and core thickness are important variables in designing low heat release interior panels. Author

A90-33924#
FLIGHT TEST SAFETY AND 'HIGH RISK' TESTS - THE AERITALIA APPROACH
P. DURANTI and G. GAMALERO (Aeritalia S.p.A., Caselle Torinese, Italy) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 376-386. refs
(AIAA PAPER 90-1315) Copyright

An account is given of the procedures developed by a major military aircraft manufacturer to manage the safety aspects of flight testing over a series of aircraft modifications, using the illustrative case of the AM-X ground attack aircraft. An evaluation is made of the risk management-incorporating procedures employed in the AM-X's fly-by-wire controlled engine-restarting by windmilling, and in its high angle-of-incidence departure behavior trials. These tests clearly defined the borderline between manageable risk and unsafe areas of operation. O.C.

N90-20054# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Aerospace Medical Panel.
IMPLICATIONS OF ADVANCED TECHNOLOGIES FOR AIR AND SPACECRAFT ESCAPE
Feb. 1990 108 p In ENGLISH and FRENCH Symposium held in Munich, Fed. Republic of Germany, 24-28 Apr. 1989
(AGARD-CP-472; ISBN-92-835-0539-5; AD-A219223) Copyright Avail: NTIS HC A06/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

With reduction of escape fatalities or injuries and improvement of out-of-the envelope ejection safety as primary goals, this Symposium addressed the latest technological advances in all areas which affect overall escape system performance and capabilities. Escapes from hypersonic vehicles and spacecraft were also considered.

N90-20057# Institute of Aviation Medicine, Farnborough (England).
DEVELOPMENT OF AN EJECTION SEAT SPECIFICATION FOR A NEW FIGHTER AIRCRAFT
D. J. ANTON *In* AGARD, Implcations of Advanced Technologies for Air and Spacecraft Escape 7 p Feb. 1990
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The development of a new aircraft brings with it the opportunity to incorporate improvements, and new features, in the design of the escape system that experience with previous systems has shown to be necessary. Just such an opportunity occurred with the announcement of the development of the European Fighter Aircraft. The United Kingdom input to the specification of the ejection seat for this aircraft was derived from accident experience and from analysis of ejection test data from previous marks of ejection seat. The aim is to discuss the problem of impairment of consciousness on ejection, the rationale for improvements in ejection seat stability, and measures taken to improve ejection seat headbox impact attenuation. Author

N90-20058# Royal Aerospace Establishment, Farnborough (England).
ESCAPE SYSTEMS RESEARCH AT RAE
D. J. GILSON *In* AGARD, Implications of Advanced Technologies for Air and Spacecraft Escape 15 p Feb. 1990
Copyright Avail: NTIS HC A06/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

A range of recent topics in the escape systems research program at the Establishment is described. Prominent among these is the computer simulation of ejection seat dynamics which enables prediction of the behavior of escape systems in different conditions, and complements the experimental methods of investigation. Other topics described include passive methods of seat stabilization using plates to supplement a bridle-mounted drogue, use of a reefed drogue to improve deceleration characteristics, consideration of some methods of deceleration, and use of inflatable restraint devices. Electronic sequencer developments are described, leading to provision of a high capacity, high reliability sequencer for trials use. A Biodynamic modeling and dummy development are considered. Author

N90-20059# Martin-Baker Aircraft Co. Ltd., Denham (England).
FIGHTER ESCAPE SYSTEM: THE NEXT STEP FORWARD
B. A. MILLER *In* AGARD, Implications of Advanced Technologies for Air and Spacecraft Escape 6 p Feb. 1990
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Ejection seats have become increasingly complex, heavier and bulkier in recent years. This growth in response to the increasing demands for greater performance, under more severe conditions. It is also due to the relocation onto the seat of equipment which was previously aircraft mounted such as anti-g valve, oxygen regulator, NBC equipment, and OBOGS auxiliary oxygen equipment. In the Tornado, the Mk10A ejection seat even gained outlets for the cabin conditioning system, becoming the world's first air conditioned ejection seat. This trend has persisted for some 15 years, but now new design derivers are becoming dominant with an increasing and urgent need for lightweight and low cost. The Martin-Baker developments of the past 15 years are briefly reviewed and the new trends which are shaping future Fighter Escape Systems discussed. Author

N90-20060# Douglas Aircraft Co., Inc., Long Beach, CA.
POTENTIAL ROLE OF AVIONICS IN ESCAPE SYSTEMS
JAMES J. SCHOEN *In* AGARD, Implications of Advanced Technologies for Air and Spacecraft Escape 4 p Feb. 1990
Copyright Avail: NTIS HC A06/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The role of avionics in escape systems for high-performance aircraft is rapidly expanding. In the most advanced systems currently in service, an electronic controller, in conjunction with mechanical sensors, selects the recovery sequence and controls event timing. More advanced avionics systems under development feature improved microprocessors and solid-state sensors. These slightly improve performance by modifying system timing based on airspeed and altitude conditions. They also introduce desirable black-box features such as built-in-test and fault isolation. Avionics has the potential to contribute far more to escape systems based on the current development of controllable propulsion systems. Typically these systems would consist of multiple rocket engines under the command of a microprocessor/controller. The controllable propulsion system would control attitude and would also control the acceleration forces on the crew member. The avionics system would therefore include attitude and acceleration sensors. In smarter systems,the propulsion system could be used to control the escape trajectory for ground avoidance or to reduce forces on the crew member in an escape under benign conditions. Thus, the avionics system may include ground direction and proximity sensors. Real-time control of an escape system vehicle under the dynamic conditions associated with high airspeed or rapid maneuvering requires a comprehensive avionics system with high-frequency response. However, the technology is available, and this type of system could be a basic feature of any next-generation escape system. Author

N90-20063# Aerospace Medical Research Labs., Wright-Patterson AFB, OH. Human Systems Div.
WINDBLAST PROTECTION FOR ADVANCED EJECTION SEATS
LAWRENCE J. SPECKER and JAMES W. BRINKLEY *In* AGARD, Implications of Advanced Technologies for Air and Spacecraft Escape 11 p Feb. 1990
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The United States Air Force is currently engaged in an advanced development program to demonstrate the feasibility of extending the capability of open ejection seats to 700 KEAS. The probability of injury at this airspeed is estimated to be 100 percent, based on the current injury statistics. Past approaches to windblast protection have involved the use of harnesses and limb tethers which have proved to be unacceptable to pilots. Therefore, advanced unencumbering techniques are required to provide the needed protection. The USAF has developed and tested a windblast protection concept that utilizes high-strength, deployable fabric panels. The panels capture and slow the aerodynamic flow impinging on the ejection seat occupant's extremities and torso and reduce the probability of windblast induced flail injury. Wind tunnel tests were conducted in low- and high-speed wind tunnels using one-half scale models of a fiftieth percentile crewman and ejection seat as well as full-scale manikins and modified ACES 2 ejection seats equipped with the flow-stagnation panels. The tests were accomplished to determine the degree of protection for the crewmember, the influence of the flow-stagnation panels on ejection seat aerodynamics, and the effects of design changes to the panel shape and material. The wind tunnel tests have demonstrated the protective potential of the flow-stagnation concept, but classical aerodynamic and windblast tests have indicated the configuration of the panels is critical to the protection of the crewmember's head. Configuration of the panels is also critical for the reduction of the total loads acting on the crewmember and seat combination. Without passive aerodynamic reduction of the forces and moments, a larger catapult and stabilization system thrust must be used to maintain stabilized flight through the ejection sequence. An overview of the flow-stagnation windblast protection system tests, the implications of its use and required future tests are discussed. Author

N90-20064# Douglas Aircraft Co., Inc., Long Beach, CA.
CONTROLLABLE PROPULSION FOR ESCAPE SYSTEMS CONTROL
A. BLAIR MCDONALD *In* AGARD, Implications of Advanced Technologies for Air and Spacecraft Escape 6 p Feb. 1990
Copyright Avail: NTIS HC A06/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Current escape systems for military aircraft use solid-grain rockets for propulsion. These provide a fixed level of thrust for a fixed period of time. Since the escape system has no function over a wide range of conditions, this approach is a compromise. Significant improvements in escape capability could be achieved by introducing a propulsion system in which the thrust-time profile could be varied to suit the circumstances of each emergency. The technology now exists to introduce a fully controllable propulsion system. Such a system would not only provide a variable thrust-time profile but would also permit the propulsion system to provide stabilization, to control the forces applied to the crew member, and to control the escape trajectory. These capabilities would allow improved system operation throughout an expanded escape envelope. The technology for a fully controllable propulsion system was already demonstrated in a development program. Author

N90-20068*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A REVIEW OF THE ANALYTICAL SIMULATION OF AIRCRAFT CRASH DYNAMICS
EDWIN L. FASANELLA, HUEY D. CARDEN, RICHARD L. BOITNOTT (Army Aviation Systems Command, Hampton, VA.), and ROBERT J. HAYDUK Jan. 1990 25 p
(NASA-TM-102595; NAS 1.15:102595) Avail: NTIS HC A03/MF A01 CSCL 01/3

A large number of full scale tests of general aviation aircraft, helicopters, and one unique air-to-ground controlled impact of a transport aircraft were performed. Additionally, research was also conducted on seat dynamic performance, load-limiting seats, load limiting subfloor designs, and emergency-locator-transmitters (ELTs). Computer programs were developed to provide designers with methods for predicting accelerations, velocities, and displacements of collapsing structure and for estimating the human response to crash loads. The results of full scale aircraft and component tests were used to verify and guide the development of analytical simulation tools and to demonstrate impact load attenuating concepts. Analytical simulation of metal and composite aircraft crash dynamics are addressed. Finite element models are examined to determine their degree of corroboration by experimental data and to reveal deficiencies requiring further development. Author

N90-20069# Dayton Univ., OH. Research Inst.
FULL-SCALE BIRDSTRIKE TESTING OF IN-SERVICE AGED F-111 ADBIRT WINDSHIELD TRANSPARENCIES Interim Report, May 1985 - Nov. 1987
DANIEL R. BOWMAN, GREGORY J. STENGER, and BLAINE S. WEST Aug. 1989 297 p
(Contract F33615-84-C-3404; AF PROJ. 1926)
(AD-A218035; UDR-TR-88-39; WRDC-TR-89-3075) Avail: NTIS HC A13/MF A02 CSCL 01/2

A test program consisting of 22 full scale birdstrike tests of F-111 ADBIRT windshield transparencies was conducted. Test hardware was developed to simulate flight structure, and four pound artificial birds were used to impact the transparencies at the most critical location, the upper inboard corner. Testing was completed on windshield panels ranging from unaged baseline windshields to windshields which had been in service for more than five years. The structural integrity of F-111 ADBIRT windshield transparencies was found to be significantly reduced by in-service aging. GRA

N90-20922*# Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, 1988-1989
ROBERT W. SIMPSON *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 1-5 Mar. 1990
Avail: NTIS HC A10/MF A02 CSCL 01/3

There are four areas of research being pursued in 1988 under sponsorship of the FAA/NASA Joint University Research Program, and one area which has been completed. The four active areas were: (1) Automatic Speech Recognition (ASR) in Air Traffic Control. The purpose of this research effort is to demonstrate the feasibility of using ASR technology within the ATC environment and to address the problems involved, especially the relevant human factors issues. (2) A Rule-Based Planning and Scheduling System. Planning denotes the formulation of a detailed scheme, program, or method worked out beforehand for the accomplishment of a goal. It involves the analysis of the desired goal and its division into sub-goals which are subsequently treated in the same way until a set of primitive objectives is obtained. (3) Modeling of Ice Accretion on Aircraft in Glaze Icing Conditions. The work in aircraft icing over the past year has focused on the fundamental aspects of glaze ice accretion, with the goal of improving analytical ice accretion models. Over the past year, studies have been conducted on the generation of surface roughness on accreting ice surfaces with the goal of providing a deterministic surface roughness in the ice accretion models. (4) Cockpit Display of Hazardous Weather Information. Information transfer and display issues associated with the dissemination of hazardous weather warnings are studied in the context of windshear alerts. Author

N90-20924*# Massachusetts Inst. of Tech., Cambridge.
COCKPIT DISPLAY OF HAZARDOUS WIND SHEAR INFORMATION
CRAIG WANKE and R. JOHN HANSMAN, JR. *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 17-34 Mar. 1990
Avail: NTIS HC A10/MF A02 CSCL 01/3

Information on cockpit display of wind shear information is given in viewgraph form. Based on the current status of windshear sensors and candidate data dissemination systems, the near-term

capabilities for windshear avoidance will most likely include: (1) Ground-based detection: TDWR (Terminal Doppler Weather Radar), LLWAS (Low-Level Windshear Alert System), Automated PIREPS; (2) Ground-Air datalinks: Air traffic control voice channels, Mode-S digital datalink, ACARS alphanumeric datalink. The possible datapaths for integration of these systems are illustrated in a diagram. In the future, airborne windshear detection systems such as lidars, passive IR detectors, or airborne Doppler radars may also become available. Possible future datalinks include satellite downlink and specialized en route weather channels. Author

N90-20925*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MODELING OF SURFACE ROUGHNESS EFFECTS ON GLAZE ICE ACCRETION
R. JOHN HANSMAN, JR., KEIKO YAMAGUCHI, BRIAN M. BERKOWITZ (Sverdrup Technology, Inc., Middleburg Heights, OH.), and MARK POTAPCZUK *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 35-42 Mar. 1990
(Contract NAG3-666; NGL-22-009-640; NSF 85-52702)
Avail: NTIS HC A10/MF A02 CSCL 01/3

A series of experimental investigations focused on studying the cause and effect of roughness on accreting glaze ice surfaces were conducted. Detailed microvideo observations were made of glaze ice accretions on 1 to 4 inch diameter cylinders in three icing wind tunnels (the Data Products of New England six inch test facility, the NASA Lewis Icing Research Tunnel, and the B. F. Goodrich Ice Protection Research Facility). Infrared thermal video recordings were made of accreting ice surfaces in the Goodrich facility. Distinct zones of surface water behavior were observed; a smooth wet zone in the stagnation region with a uniform water film; a rough zone where surface tension effects caused coalescence of surface water into stationary beads; a horn zone where roughness elements grow into horn shapes; a runback zone where surface water ran back as rivulets; and a dry zone where rime feathers formed. The location of the transition from the smooth to the rough zone was found to migrate with time towards the stagnation point. The behavior of the transition appeared to be controlled by boundary layer transition and bead formation mechanisms at the interface between the smooth and rough zones. Regions of wet ice growth and enhanced heat transfer were clearly visible in the infrared video recordings of glaze ice surfaces. A simple multi-zone modification to the current glaze ice accretion model was proposed to include spatial variability in surface roughness. Author

N90-20926*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
ULTRASONIC TECHNIQUES FOR AIRCRAFT ICE ACCRETION MEASUREMENT
R. JOHN HANSMAN, JR., MARK S. KIRBY, and FRED LICHTENFELTS (Simmonds Precision Products, Inc., Vergennes, VT.) *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 43-53 Mar. 1990 Sponsored by NSF
(Contract NAG3-666; NGL-22-009-640)
Avail: NTIS HC A10/MF A02 CSCL 01/3

Results of tests to measure ice growth in natural (flight) and artificial (icing wind tunnel) icing conditions are presented. Ice thickness is measured using an ultrasonic pulse-echo technique. Two icing regimes, wet and dry ice growth, are identified and the unique ultrasonic signal characteristics associated with these different types of ice growth are described. Ultrasonic measurements of ice growth on cylinders and airfoils exposed to artificial and natural icing conditions are presented. An accuracy of plus or minus 0.5 mm is achieved for ice thickness measurement using the pulse-echo technique. The performance of two-probe type ice detectors is compared to the surface mounted ultrasonic system. The ultrasonically measured ice accretion rates and ice surface condition (wet or dry) are used to compare the heat transfer characteristics for flight and icing wind tunnel environments. In general the heat transfer coefficient is inferred to be higher in the wind tunnel environment, not likely due to higher freestream turbulence levels. Finally, preliminary results of tests to measure ice growth on airfoil using an array of ultrasonic transducers are described. Ice profiles obtained during flight in natural icing conditions are shown and compared with mechanical and stereo image measurements. Author

N90-20927*# Massachusetts Inst. of Tech., Cambridge.
INVESTIGATION OF SURFACE WATER BEHAVIOR DURING GLAZE ICE ACCRETION
R. JOHN HANSMAN, JR. and STEPHEN R. TURNOCK (Southampton Univ., England) *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 55-62 Mar. 1990
(Contract NAG3-666; NGL-22-009-640; NSF 85-52702)
Avail: NTIS HC A10/MF A02 CSCL 01/3

A series of experimental investigations that focused on isolating the primary factors that control the behavior of unfrozen surface water during glaze ice accretion were conducted. Detailed microvideo observations were made of glaze ice accretions on 2.54 cm diam cylinders in a closed-loop refrigerated wind tunnel. Distinct zones of surface water behavior were observed; a smooth wet zone in the stagnation region with a uniform water film, a rough zone where surface tension effects caused coalescence of surface water into stationary beads, and a zone where surface water ran back as rivulets. The location of the transition from the smooth to the rough zone was found to migrate towards the stagnation point with time. Comparative tests were conducted to study the effect of the substrate thermal and roughness properties on ice accretion. The importance of surface water behavior was evaluated by the addition of a surface tension reducing agent to the icing tunnel water supply, which significantly altered the accreted glaze ice shape. Measurements were made to determine the contact angle behavior of water droplets on ice. A simple multizone modification to current glaze ice accretion models was proposed to include the observed surface roughness behavior. Author

N90-20928*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
THE INFLUENCE OF ICE ACCRETION PHYSICS ON THE FORECASTING OF AIRCRAFT ICING CONDITIONS
R. JOHN HANSMAN, JR. *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 63-67 Mar. 1990 Sponsored by NSF
(Contract NAG3-666; NGL-22-009-640)
Avail: NTIS HC A10/MF A02 CSCL 01/3

The physics which control aircraft ice accretion are reviewed in the context of identifying and forecasting hazardous icing conditions. The severity of aircraft icing is found to be extremely sensitive to temperature, liquid water content and droplet size distribution particularly near the transition between rime and mixed icing. The difficulty in measurement and the variability of these factors with altitude, position and time coupled with variable aircraft sensitivity make forecasting and identifying icing conditions difficult. Automated Pilot Reports (PIREPS) are suggested as one mechanism for improving the data base necessary to forecast icing conditions. Author

N90-20929*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
COCKPIT DISPLAY OF HAZARDOUS WEATHER INFORMATION
R. JOHN HANSMAN, JR. and CRAIG WANKE *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 69-76 Mar. 1990
(Contract NAG1-690; NGL-22-009-640; BARR-10-119)
Avail: NTIS HC A10/MF A02 CSCL 01/3

Information transfer and display issues associated with the dissemination of hazardous weather warnings are studied in the context of windshear alerts. Operational and developmental windshear detection systems are briefly reviewed. The July 11, 1988 microburst events observed as part of the Denver Terminal

Doppler Weather Radar (TDWR) operational evaluation are analyzed in terms of information transfer and the effectiveness of the microburst alerts. Information transfer, message content and display issues associated with microburst alerts generated from ground based sources are evaluated by means of pilot opinion surveys and part task simulator studies. Author

N90-20934*# Ohio Univ., Athens. Avionics Engineering Center.
WEATHER DATA DISSEMINATION TO AIRCRAFT
RICHARD H. MCFARLAND and CRAIG B. PARKER *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 119-127 Mar. 1990
Avail: NTIS HC A10/MF A02 CSCL 01/3

Documentation exists that shows weather to be responsible for approximately 40 percent of all general aviation accidents with fatalities. Weather data products available on the ground are becoming more sophisticated and greater in number. Although many of these data are critical to aircraft safety, they currently must be transmitted verbally to the aircraft. This process is labor intensive and provides a low rate of information transfer. Consequently, the pilot is often forced to make life-critical decisions based on incomplete and outdated information. Automated transmission of weather data from the ground to the aircraft can provide the aircrew with accurate data in near-real time. The current National Airspace System Plan calls for such an uplink capability to be provided by the Mode S Beacon System data link. Although this system has a very advanced data link capability, it will not be capable of providing adequate weather data to all airspace users in its planned configuration. This paper delineates some of the important weather data uplink system requirements, and describes a system which is capable of meeting these requirements. The proposed system utilizes a run-length coding technique for image data compression and a hybrid phase and amplitude modulation technique for the transmission of both voice and weather data on existing aeronautical Very High Frequency (VHF) voice communication channels. Author

N90-20935*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT PRINCETON UNIVERSITY, 1988-1989
ROBERT F. STENGEL *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 131-144 Mar. 1990
Avail: NTIS HC A10/MF A02 CSCL 01/3

The Air Transportation Technology Program at Princeton University, a program emphasizing graduate and undergraduate student research, proceeded along several avenues during the past year. A study of optimal trajectories for penetration of microbursts when encounter is unavoidable was conducted. The emphasis of current wind shear research is on developing an expert system for wind shear avoidance. A knowledge-based reconfigurable flight control system that is implemented with the Pascal programming language using parallel microprocessors was developed. This expert system could be considered a prototype for a failure-tolerant control system that can be constructed using existing hardware. Development of a real-time cockpit simulator continued during the year. The simulator provides a single-person crew station with both conventional and advanced control devices; it currently is programmed to simulate the Navion single-engine general aviation airplane. Alternatives for the air traffic control system giving particular attention to the institutional structure of the FAA are analyzed. A simple numerical procedure for estimating the stochastic robustness of control systems is being investigated. The revitalization of the general aviation industry is also discussed. Author

N90-20938*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
AN EXPERT SYSTEM FOR WIND SHEAR AVOIDANCE
ROBERT F. STENGEL and D. ALEXANDER STRATTON *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 183-188 Mar. 1990
(Contract NAG1-834)
Avail: NTIS HC A10/MF A02 CSCL 01/3

A study of intelligent guidance and control concepts for protecting against the adverse effects of wind shear during aircraft takeoffs and landings is being conducted, with current emphasis on developing an expert system for wind shear avoidance. Principal objectives are to develop methods for assessing the likelihood of wind shear encounter (based on real-time information in the cockpit), for deciding what flight path to pursue (e.g., takeoff abort, landing go-around, or normal climbout or glide slope), and for using the aircraft's full potential for combating wind shear. This study requires the definition of both deterministic and statistical techniques for fusing internal and external information , for making go/no-go decisions, and for generating commands to the manually controlled flight. The program has begun with the development of the WindShear Safety Advisor, an expert system for pilot aiding that is based on the FAA Windshear Training Aid; a two-volume manual that presents an overview , pilot guide, training program, and substantiating data provides guidelines for this initial development. The WindShear Safety Advisor expert system currently contains over 200 rules and is coded in the LISP programming language. Author

N90-20966# National Transportation Safety Board, Washington, DC.
ANNUAL REVIEW OF AIRCRAFT ACCIDENT DATA: US GENERAL AVIATION CALENDAR YEAR 1987
12 Dec. 1989 87 p
(PB90-138066; NTSB/ARG-89/01) Avail: NTIS HC A05/MF A01 CSCL 01/3

A statistical compilation and review is presented of general aviation accidents which occurred in 1987 in the United States, its territories and possessions, and in international waters. The accidents reported are all those involving U.S. registered aircraft not conducting operations under 14 CFR 121, 14 CFR 125, 14 CFR 127, or 14 CFR 135. There are five sections: (1) All Accidents; (2) Fatal Accidents; (3) Serious Injury Accidents; (4) Property Damage Accidents; and (5) Midair Collision Accidents. Several tables present accident parameters for 1987 accidents only, and each section includes tabulations which present comparative statistics for 1987 and for the five-year period 1982 to 1986. Author

N90-20967# Federal Aviation Administration, Atlantic City, NJ.
FULL-SCALE AIR TRANSPORT CATEGORY FUSELAGE BURNTHROUGH TESTS
HARRY WEBSTER, GEORGE GEYER, DUNG DO, JOSEPH WRIGHT, JOHN COLLINS, and LAWRENCE HAMPTON Feb. 1990 33 p
(DOT/FAA/CT-TN89/65) Avail: NTIS HC A03/MF A01

The observations, test data, and conclusions obtained during the course of six full-scale fuselage burnthrough tests are presented. A comprehensive data base was developed which represented the flammability resistance of an intact fuselage when exposed to an exterior fuel fire. Three tests were conducted with the fuselage on the ground simulating a wheels-up condition, and three tests were conducted with the wheels down. Test results: (1) the aluminum skin provides protection from a fully developed fuel fire for 30 to 60 seconds; (2) the fiberglass acoustical insulation is an effective thermal barrier; (3) flame penetration into the cheek area provides a fire path into the cabin through the floor air return grills; (4) the aircraft with its gear extended is more vulnerable to burnthrough from a pool fire than an aircraft resting on its belly; and (5) areas, such as the empennage crawlthrough, that are not acoustically insulated are more vulnerable to burnthrough than other parts of the insulated fuselage. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A90-31938
DEVELOPMENT OF AIR-TO-AIR LASER COMMUNICATIONS
ROBERT J. FELDMANN (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Space sensing, communications, and networking; Proceedings of the Meeting, Los Angeles, CA, Jan. 16-18, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 98-102.
Copyright

The paper discusses problems of operational utility in the employment of airborne laser communications technology, and aims to identify those missions, present and future, whose communications requirements are best satisfied through the use of affordable laser systems. The application of laser communications in such scenarios as Strategic Data Exchange (SDE) and aircraft formation positioning are discussed. Ways to reduce and eliminate shortcomings of conventional laser systems (such as high cost and high probability of pointing errors) are examined; and devices (multibeam laser phased steering arrays, multiaperture compound eye configurations, and others) proposed for future research and development by the Laser Acquisition Study, are reviewed. N.B.

A90-33348
TCAS FOR COMMUTER AIRCRAFT
DANIEL H. TILLOTSON (Arinc Research Corp., Annapolis, MD) Aerospace Engineering (ISSN 0736-2536), vol. 10, May 1990, p. 23-25.
Copyright

A process for upgrading commuter aircraft mid-air collision avoidance systems, for use in the U.S. ATC system is presented. The plan is to pattern the TCAS I evaluation program after those previous evaluations designed for high-performance commercial aircraft, using a 10-30 seat turboprop commuter that is representative of normal regional air carrier operations. The technical specification recognizes that TCAS I surveillance reliability for a given range and density will depend on other environmental characteristics, including the total interrogation rate in the vicinity and the density of interrogators transmitting Mode S broadcasts. The eventual implementation of an effective traffic alert and collision avoidance system for commuter aircraft is expected to result in a safer overall ATC system. R.E.P.

A90-33613
CONCEPT OF AN MTI SEARCH LADAR
NICHOLAS GRAMENOPOULOS (Mitre Corp., McLean, VA) IN: Laser radar IV; Proceedings of the Meeting, Orlando, FL, Mar. 29, 30, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 139-150. refs
Copyright

Ladars have been designed for various applications but not adequately explored for airborne surveillance. A Moving Target Indicator (MTI) ladar concept is presented capable of detecting small aircraft at long ranges. Atmospheric attenuation for cloud-free lines of sight is controlled by operating wavelength selection and avoidance of long horizontal paths through the lower atmosphere. Atmospheric turbulence effects were found to be insignificant. The performance of the ladar is analyzed, and subsystem requirements for lasers, detectors and spectrum analyzers are developed. A computer simulation capability was developed that allows the prediction of the ladar signatures of aircraft. Author

A90-33914#
INTEGRATED SYSTEM OF DIFFERENTIAL GLOBAL POSITIONING SYSTEM AND INERTIAL MEASUREMENT UNIT - A POSITION DETERMINATION SYSTEM FOR AUTOMATIC LANDING
THOMAS JACOB and G. SCHAENZER (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 283-290. refs
(AIAA PAPER 90-1300) Copyright

In the present system concept for high precision aircraft flight path/attitude information determination, differential GPS data are integrated into a hybrid system. Accuracy-related problems due to the influence of maneuvering dynamics on GPS receivers are addressed by the design of a Flight Guidance System able to yield approach and landing guidance up to category III, irrespective of the availability of ILS or MLS. The system is based on the closed-loop mechanization of a Kalman filter that couples GPS to inertial measurement units. Results are presented from flight tests conducted for this system aboard a Do128 commuter aircraft. O.C.

A90-33915#
AUTOMATIC LANDING WITH GPS - DESIGN OF THE FLIGHT GUIDANCE AND FLIGHT CONTROL SYSTEM
MANFRED DIEROFF and G. SCHAENZER (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 291-296. refs
(AIAA PAPER 90-1301) Copyright

An account is given of the architecture and flight test performance of a fully automatic landing system using the differential GPS technique. It is shown that GPS-based approaches indistinguishable from those obtainable with ILS can be performed, while avoiding shortcomings associated with ILS. The use of a multivariable state controller with an inverse flight mechanics model of the aircraft, as well as its feedforward laws, allows the execution of curved flight paths with great precision. The user may autonomously generate any desired flight path, thereby helping alleviate future ATC aircraft proximity problems encountered during landing approaches. O.C.

A90-33923#
DEVELOPMENTS IN AUTOMATION OF FLIGHT TEST ANALYSIS AND REPORT GENERATION
MICHAEL J. DESROSIERS, HILLARD A. ROSEN, and STEVEN LOPES (U.S. Navy, Naval Underwater Systems Center, Newport, RI) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 359-375. refs
(AIAA PAPER 90-1313)

In order to meet program objectives for consistent, timely, and thorough flight test reports during developmental testing of the Submunitions TOMAHAWK Land-Attack Missile, an Automated Flight Test Analysis and Report Writing Tool was developed by the Naval Underwater Systems Center, Newport, Rhode Island. This paper discusses the methods used to standardize flight test reports, design the flight test database, select hardware and software components, reduce and store flight test data, filter missile telemetry (TM) data, standardize and automate analysis efforts, and generate the automated report. Results included: use of a relational database to store large amounts of planned and actual flight test data; development of an auto-correlation routine to link TM data with planned mission data; application of heuristic techniques to filter individual TM channels; and, standardization and automation of analysis efforts for submunitions impact-point density, boost phase, Terrain Contour Matching, and terrain following performance evaluation. Automated flight test report

generation reduced the report preparation period from an average of six months to two months and improved reporting accuracy and consistency. Author

A90-33925#
PREPARATIONS OF THE REAL-TIME DATA ANALYST TO INSURE FLIGHT TEST SAFETY
GERALD L. DITTMANN (General Dynamics Corp., Convair Div., San Diego, CA) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 387-392.
(AIAA PAPER 90-1316) Copyright

A systematic approach is presented for the preparation of flight tests to maximize safety, giving attention to a real-time chart-recorder setup and its data display system and the organization and preparation of a data-analysis team. A data-analyst review procedure is formulated which allows preparation discrepancies to be detected prior to testing, and facilitates that knowledge is shared among team members. The procedure, which tests participant knowledge under stressful, 'real-time' conditions, investigates various possible hazardous situations. O.C.

A90-34137
SHADOW-TRACKING ALGORITHM FOR MOVING TARGET DETECTION
W. CARRARA, C. ROUSSI, and S. WERNESS (Michigan, Environmental Research Institute, Ann Arbor) IN: Millimeter wave and synthetic aperture radar; Proceedings of the Meeting, Orlando, FL, Mar. 27, 28, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 129-139.
Copyright

A 'notch' algorithm has been devised for the detection of ground-moving targets in SAR imagery, whose performance is independent of the direction of target movement, due to its use of the shadow characteristics of a target moving over a cluttered background. The notch algorithm attempts to find the target ground-track, and to estimate its velocity, on the basis of a single, cohesive radar datum which is indicative of the phase-compensation required to begin a refocusing of the target. Simulation results are presented which illustrate the algorithm's performance over a range of target velocities. O.C.

A90-34138
DOPPLER-RATE FILTERING FOR DETECTING MOVING TARGETS WITH SYNTHETIC APERTURE RADARS
S. BARBAROSSA (Roma I, Universita, Rome, Italy) IN: Millimeter wave and synthetic aperture radar; Proceedings of the Meeting, Orlando, FL, Mar. 27, 28, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 140-147. refs
Copyright

Doppler-filtering methods for SAR detection of moving targets are inadequate in the cases of targets with low radial velocity with respect to the radar, as well as in virtue of the radar-coverage loss associated with the use of pulse-repetition frequencies that are higher than that of clutter bandwidths. In order to overcome these shortcomings, a technique has been devised on the basis of the difference in the Doppler frequency rate and spatial correlation between moving and fixed targets. After adaptive filtering to improve the moving-to-fixed target power ratio, the signal is passed through a bank of Doppler-rate filters. Each of the constituent filters is matched to a specific Doppler rate. O.C.

A90-34140
VISION GUIDANCE UPDATE - SYNTHETIC APERTURE RADAR (SAR) MULTIPLE IMAGE EXPLOITATION FOR POSITION AND VELOCITY DETERMINATION
ARTHUR C. KENTON, JAMES A. WRIGHT, and JAMES C. NELANDER (Michigan, Environmental Research Institute, Niceville, FL) IN: Millimeter wave and synthetic aperture radar; Proceedings of the Meeting, Orlando, FL, Mar. 27, 28, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 158-169. Research supported by the Environmental Research Institute of Michigan.
Copyright

The SAR multiimage exploitation technique designated 'Vision Guidance Update' (VGU) employs radar vision from range-angle imagery of stationary ground features to yield precision navigational position and velocity estimates for platforms requiring long-range, all-weather, day/night sensing capability. VGU analyzes the changes in perspective of features in successive SAR spotlight images, solving the coupled-geometry problem to ascertain precision platform velocity and position estimates. Attention is presently given to the estimation errors that arise from realistic SAR systems' finite-resolution effects. O.C.

A90-34143
ADVANCED TECHNOLOGY MMW SEEKER TESTBED, A MULTI-TECHNOLOGY DEMONSTRATION SENSOR
JAMES H. HUGHEN and GARY A. KILLEN (Martin Marietta Electronic Systems, Orlando, FL) IN: Millimeter wave and synthetic aperture radar; Proceedings of the Meeting, Orlando, FL, Mar. 27, 28, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 196-203. refs
Copyright

The Advanced Technology Millimeter-Wave Seeker Testbed (ATMMWST) uses synthetic coherent processing to achieve high rate resolution, a complete polarization scattering matrix, and dual-plane sum-and-difference monopulse with complex angle processing. The seeker is coupled to statistical pattern-recognition algorithms for target-clutter discrimination, as well as tracking algorithms for guidance signal generation; these algorithms are embedded in the signal processing software/hardware system. ATMMWST consists of a seeker, a signal processor, an instrumentation/data-recording system, and an independent line-of-sight reference system. O.C.

A90-34146
SIMULATION OF AIRBORNE TARGET IMAGERY - DEPENDENCE ON FREQUENCY AND BISTATIC ANGLE
C. CHA and S. ROTH (Syracuse Research Corp., NY) IN: Millimeter wave and synthetic aperture radar; Proceedings of the Meeting, Orlando, FL, Mar. 27, 28, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 221-224.
Copyright

An investigation is presented of signature-simulation generic airborne targets, giving attention to target shapes as functions of frequency and bistatic angle between the transmitter and receiver lines-of-sight. After simulating the radar cross-section (RCS) for monochromatic waves, image response is derived on the basis of Fourier transforms in frequency and time. Accurate bistatic RCS is simulated by evaluating both the physical optics and the diffraction components with a uniform asymptotic analysis. Attention is also given to image quality vs bistatic angle in a bistatic configuration; the bistatic equivalent theorem is examined by comparing the image corresponding to the equivalent monostatic case to that of a more accurate prediction for the exact bistatic case. O.C.

N90-20923*# Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
AUTOMATIC SPEECH RECOGNITION IN AIR TRAFFIC CONTROL
JOAKIM KARLSSON *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 7-15 Mar. 1990
Avail: NTIS HC A10/MF A02 CSCL 01/3

Automatic Speech Recognition (ASR) technology and its application to the Air Traffic Control system are described. The advantages of applying ASR to Air Traffic Control, as well as criteria for choosing a suitable ASR system are presented. Results from previous research and directions for future work at the Flight Transportation Laboratory are outlined. Author

N90-20931*# Ohio Univ., Athens.
RIDGE REGRESSION PROCESSING
MARK R. KUHL *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 99-104 Mar. 1990
Avail: NTIS HC A10/MF A02 CSCL 01/3

Current navigation requirements depend on a geometric dilution of precision (GDOP) criterion. As long as the GDOP stays below a specific value, navigation requirements are met. The GDOP will exceed the specified value when the measurement geometry becomes too collinear. A new signal processing technique, called Ridge Regression Processing, can reduce the effects of nearly collinear measurement geometry; thereby reducing the inflation of the measurement errors. It is shown that the Ridge signal processor gives a consistently better mean squared error (MSE) in position than the Ordinary Least Mean Squares (OLS) estimator. The applicability of this technique is currently being investigated to improve the following areas: receiver autonomous integrity monitoring (RAIM), coverage requirements, availability requirements, and precision approaches. Author

N90-20932*# Ohio Univ., Athens.
OPTIMIZATION OF THE EFFECTIVE GPS DATA RATE
DAVID S. MCINTYRE *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 105-109 Mar. 1990
Avail: NTIS HC A10/MF A02 CSCL 01/3

Ohio University's Avionics Engineering Center is performing research directed towards the integration of the NAVSTAR Global Positioning System (GPS) and the Inertial Navigation System (INS) for attitude and heading determination. The integration of GPS/INS offers synergistic benefits. INS gyro drift error can be compensated by the long-term stability of GPS by means of an in-flight data monitoring algorithm. Using GPS data as a reference is more advantageous than implementing an additional INS since GPS offers a dissimilar redundancy to the attitude and heading determination configuration. In converse, the short-term stability of the INS can be used to correct or substitute for faulty GPS data due to tracking loop phase lag or data gaps because of satellite shielding. The optimization of the effective GPS data rate is essential for the proper execution of an integrated GPS/INS in-flight algorithm. GPS attitude and heading information must be consistently available during INS outages. Present research efforts involve the development of an in-flight algorithm that maximizes the potential of integrated GPS/INS. This algorithm determines the acceptable limits of phase lag that the GPS tracking loop introduces to the flight control system (FCS) during the transmission of information. Once these calculated limits are exceeded, INS data are used to insure the continuous availability of attitude and heading information to the flight control system. Author

N90-20933*# Ohio Univ., Athens. Avionics Engineering Center.
SOLE MEANS NAVIGATION AND INTEGRITY THROUGH HYBRID LORAN-C AND NAVSTAR GPS
FRANK VANGRAAS *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 111-118 Mar. 1990
(Contract NGR-009-017)
Avail: NTIS HC A10/MF A02 CSCL 01/3

A sole means navigation system does not only call for integrity, but also for coverage, reliability, availability and accuracy. Even though ground monitored GPS will provide integrity, availability is still not sufficient. One satellite outage can affect a large service area for several hours per day. The same holds for differential GPS; a total satellite outage cannot be corrected for. To obtain sufficient coverage, extra measurements are needed, either in the form of extra GPS satellites (expensive) or through redundant measurements from other systems. LORAN-C is available and will, hybridized with GPS, result in a system that has the potential to satisfy the requirements for a sole means navigation system for use in the continental United States. Assumptions are made about the qualification sole means, mainly based on current sole means systems such as VOR/DME. In order to allow for system design that will satisfy sole means requirements, it is recommended that a definition of a sole means navigation system be established. This definition must include requirements for availability, reliability, and integrity currently not specified. In addition to the definition of a sole means navigation system, certification requirements must be established for hybrid navigation systems. This will allow for design and production of a new generation of airborne navigation systems that will reduce overall system costs and simplify training procedures. Author

N90-20968# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
PLAN FOR THE FAA AIR TRAFFIC OPERATIONAL EVALUATION OF THE AUTOMATED SURFACE OBSERVING SYSTEM (ASOS)
ELIZABETH TURCICH and BRUCE E. WARE (Data Transformation Corp., Houston, TX.) Nov. 1989 26 p
(DOT/FAA/CT-TN89/56) Avail: NTIS HC A03/MF A01

The Automated Surface Observing System (ASOS) is a weather collection and display system that will be installed in Air Traffic Control Towers (ATCT). The system will be procured, installed, operated, and maintained by the National Weather Service (NWS) for the Federal Aviation Administration (FAA) under a Memorandum of Agreement (MOA). This plan outlines the FAA's operational evaluation of the preproduction ASOS systems. Two companies, Magnavox and AAI Corporation, are under contract to develop the ASOS. The FAA will evaluate the Magnavox system at the Wichita ATCT and AAI's system at the Tulsa ATCT. The 6-week evaluations of each system will be the only FAA operational test of the ASOS. Data will be collected via questionnaires completed by Air Traffic Control Specialists (ATCS) at both sites and ATCSs brought in from other sites to assess the system. The results of the evaluation will be used for consideration in the production contract award and for making any necessary changes to the system. Author

N90-20969*# Mayflower Communications Co., Inc., Reading, MA.
AUTONOMOUS INTEGRATED GPS/INS NAVIGATION EXPERIMENT FOR OMV. PHASE 1: FEASIBILITY STUDY
TRIVENI N. UPADHYAY, GEORGE J. PRIOVOLOS, and HARLEY RHODEHAMEL Washington NASA Jan. 1990 93 p
(Contract NAS8-38031)
(NASA-CR-4267; NAS 1.26:4267) Avail: NTIS HC A05/MF A01 CSCL 17/7

The phase 1 research focused on the experiment definition. A tightly integrated Global Positioning System/Inertial Navigation System (GPS/INS) navigation filter design was analyzed and was shown, via detailed computer simulation, to provide precise position, velocity, and attitude (alignment) data to support navigation and attitude control requirements of future NASA missions. The application of the integrated filter was also shown to provide the opportunity to calibrate inertial instrument errors which is particularly useful in reducing INS error growth during times of GPS outages. While the Orbital Maneuvering Vehicle (OMV) provides a good target platform for demonstration and for possible flight implementation to provide improved capability, a successful proof-of-concept ground demonstration can be obtained using any simulated mission scenario data, such as Space Transfer Vehicle, Shuttle-C, Space Station. Author

N90-20970# National Aeronautical Lab., Bangalore (India). Flight Mechanics and Controls Div.
FLIGHT PATH RECONSTRUCTION USING EXTENDED KALMAN FILTERING TECHNIQUES
V. PARAMESWARAN and E. PLAETSCHKE Jan. 1990 76 p
(PD-FC-9001) Avail: NTIS HC A05/MF A01

An algorithm for the flight path reconstruction of state variables and for estimation of unknown constant bias and scale factor errors in measured data using extended Kalman filter and fixed interval smoother was developed. The models are based on the six-degree-of freedom kinematic equations relating measured aircraft responses. The technique is demonstrated with the aid of

typical examples using flight test data. Also some sensitivity studies on the variation of noise covariance matrices were performed. The results of FPR using extended Kalman filter and maximum likelihood methods are presented. Finally aerodynamic estimation was carried out with a simple linear model on different data sets names: (1) flight measured data not corrected for bias and scale factor errors; (2) using EKF corrected data; and (3) using ML corrected data. Author

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A90-31519
STRENGTH SUBSTANTIATION OF THE ALL COMPOSITE AIRFRAME (A MATERIALS DATA BASE APPROACH)
RIC ABBOTT and ANN L. KOLARIK (Beech Aircraft Corp., Wichita, KS) IN: International SAMPE Symposium and Exhibition, 34th, Reno, NV, May 8-11, 1989, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 283-289. Research supported by the Beech Aircraft Corp.
Copyright
Beech Aircraft has completed Federal Aviation Administration certification of the all-composite Starship 1 business airplane. This paper describes development of the data base for graphite/epoxy thermoset materials along with the tests and analysis methods used to satisfy Federal Aviation Regulations (FAR Part 23) and the special conditions pertaining to composite certification. Author

A90-31558
HONEYCOMB SANDWICH PRIMARY STRUCTURE APPLICATIONS ON THE BOEING MODEL 360 HELICOPTER
STEVEN LLORENTE (Boeing Helicopters, Philadelphia, PA) IN: International SAMPE Symposium and Exhibition, 34th, Reno, NV, May 8-11, 1989, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 824-838.
Copyright
This report presents information regarding the use and evaluation of sandwich structure throughout development and support of the Boeing Model 360. Kevlar sandwich panels, which are significantly more impact resistant than comparable graphite panels, were utilized in both side skin panels (with and without windows) and crown skin panels. Sandwich construction was also used in frames and longerons to maximize bending efficiency. The rotor blades of the Model 360 utilize graphite and fiberglass over Nomex honeycomb core. Author

A90-32257#
PRACTICAL DESIGN CONSIDERATIONS FOR INTEGRATING THE PROPULSION SYSTEM WITH THE AIRCRAFT FOR JETBORNE FLIGHT
D. B. GROLL and T. R. BOSSART (McDonnell Aircraft Co., Saint Louis, MO) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 112, April 1990, p. 192-198.
(ASME PAPER 89-GT-310) Copyright
Results of a pilot-in-the-loop simulator evaluation for engine and configuration variations to the AV-8B Harrier II aircraft are presented. Configurations were tested for various center of gravity locations, weights, pitching, moments of inertia, and thrust center locations in jetborne flight. The effects of the propulsion system's characteristics in relation to aircraft parameters are generalized with regard to pitch handling qualities such as control power, pitch sensitivity, disturbance susceptibility, and control margin. A proposed modification to improve pitch handling qualities also was evaluated and results for this modification are discussed. Author

A90-32260#
CONFIGURATION E-7 SUPERSONIC FIGHTER/ATTACK TECHNOLOGY PROGRAM
J. E. JENISTA and D. S. BODDEN (General Dynamics Corp., Fort Worth, TX) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 112, April 1990, p. 212-216. refs
(ASME PAPER 89-GT-308) Copyright
The program covering the design and early technology development of configuration E-7, a supersonic STOVL fighter/attack aircraft, is described. This aircraft uses the ejector principle to augment engine fan air for vertical lift. The initial design objectives selected in 1980 are listed and discussed. Some design considerations applicable to the propulsion concept and the chosen configuration are mentioned. The test program accomplished thus far, including wind tunnel models plus other test articles and activities, is outlined. The program has proceeded without major technological obstacles, and a full-scale engine-powered model will soon be ready for testing. Author

A90-32452#
CALCULATIONS OF PROPELLER/AIRFRAME INTERFERENCE EFFECTS USING THE POTENTIAL/MULTIENERGY FLOW METHOD
T. Q. DANG (Douglas Aircraft Co., Long Beach, CA) AIAA Journal (ISSN 0001-1452), vol. 28, May 1990, p. 771-777. Research sponsored by McDonnell Douglas Corp. refs
Copyright
This paper describes an analytical/computational model to predict propeller/airframe interference effects. In the present method, the propeller is modeled by an actuator disk and is assumed to have free-vortex blading. The flowfield consists of two potential flow regions of different stagnation conditions separated by a bound-vortex sheet located at the actuator disk and a free-vortex sheet located on the propeller slipstream. A newly developed technique of handling these vortex sheets is embedded into an existing finite-volume, full-potential code to analyze the flowfield. Comparisons of the results obtained using the present model to those from dissimilar models and some experimental data indicate that this simple method is adequate for integration studies of current ultra-high-bypass (UHB)-powered aircraft ranging from the subsonic takeoff/climbing flow regime to the transonic cruising condition. Author

A90-33057#
COMPARISON OF TEST SIGNALS FOR AIRCRAFT FREQUENCY DOMAIN IDENTIFICATION
PETER YOUNG and RONALD J. PATTON (York, University, England) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, May-June 1990, p. 430-438. Research supported by SERC and Royal Aircraft Establishment. Previously cited in issue 21, p. 3487, Accession no. A88-50593. refs
Copyright

A90-33059*# California Univ., Davis.
DESIGN AND EVALUATION OF A COCKPIT DISPLAY FOR HOVERING FLIGHT
RONALD A. HESS (California, University, Davis) and PETER J. GORDER Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, May-June 1990, p. 450-457. Previously cited in issue 22, p. 3649, Accession no. A88-51970. refs
(Contract NCC2-383)
Copyright

A90-33105* Douglas Aircraft Co., Inc., Long Beach, CA.
SUBCOMPONENT TESTS FOR COMPOSITE FUSELAGE TECHNOLOGY READINESS
R. C. MADAN and A. V. HAWLEY (Douglas Aircraft Co., Long Beach, CA) IN: International SAMPE Technical Conference, 21st,

Atlantic City, NJ, Sept. 25-28, 1989, Proceedings. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 404-418. refs
(Contract NAS1-17701)
Copyright

An account is given of a NASA research effort aimed at the development of an all-composite transport aircraft fuselage incorporating joints and cutouts which meets all design requirements. The design, construction, and analysis activities associated with the 30-ft-long fuselage section gave attention to critically important subcomponent specimens, including shear-tee pulloff specimens, stiffened and unstiffened cutout panels, longitudinal and transverse skin splices, longeron runouts, transverse skin-longerons, stiffened shear panels, and window belt panels. The analysis of large cutouts was conducted with coupling FEM analyses incorporating accurate failure criteria for tension and shear; the strategic application of S2 glass fiber plies around cutouts was demonstrated both analytically and experimentally to increase load capacity with virtually no weight penalty. O.C.

A90-33354*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF THE CAP-TSD UNSTEADY TRANSONIC SMALL DISTURBANCE PROGRAM TO WING FLUTTER
ROBERT M. BENNETT and JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 25-34. refs

The application and assessment of a computer program called CAP-TSD (Computational Aeroelasticity Program - Transonic Small Disturbance) for flutter predictions are described. Flutter calculations are presented for two thin swept-and-tapered wing planforms with well-defined modal properties. One planform is a series of 45-degree swept wings and the other planform is a clipped delta wing. Comparisons are made between the results of CAP-TSD using the linear equation and no airfoil thickness and the results obtained from a subsonic kernel function analysis. The calculations cover a Mach number range from low subsonic to low supersonic values, including the transonic range, and are compared with subsonic linear theory and experimental data. It is noted that since both wings have very thin airfoil sections, the effects of thickness are minimal. V.T.

A90-33367#
THE DEVELOPMENT OF LEADING-EDGE NOTCHES TO IMPROVE THE SUBSONIC PERFORMANCE OF WINGS OF MODERATE SWEEP
D. G. MABEY, B. L. WELSH, and C. R. PYNE (Royal Aerospace Establishment Bedford, England) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 179-186. refs

Several leading-edge notch configurations are tested on the wing of a large half-model of the High Incidence Research Model configuration at a Reynolds number of 3.6 x 10 to the 6th in a low-speed wind tunnel. The main series of experiments are made without a canard, to evaluate the effects of the wing notches on the wing separations which are larger in the absence of the favorable interference produced by the canard. It is shown that one leading-edge notch configuration reduces the wing buffeting by inhibiting the growth of the leading-edge separation bubble and also makes small improvements in the steady force characteristics. Other leading-edge notch configurations give larger improvements in the static forces but are associated with unacceptably high levels of buffeting. It is also noted that the conclusions of this study should be valid for many wings of moderate sweep, which stall by virtue of a swept bubble developing from the leading edge. V.T.

A90-33369#
ON THE PREDICTION OF THE AEROELASTIC BEHAVIOUR OF LIFTING SYSTEMS DUE TO FLOW SEPARATION
H. ZINGEL (DLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 195-204. refs

Aircraft undergo structural vibrations at separated flow which are called buffeting. The way in which these structural vibrations can be predicted on the basis of linear aeroelastic equations of motion is described for the case of a low-aspect-ratio trapezoidal half-wing model. The unsteady aerodynamic quantities were determined from wind tunnel experiments at low subsonic speed. Some characteristic features of unsteady airloads due to flow separation and motion-induced unsteady airfoils at high incidences and flow separation are presented and discussed. The dynamic response at separated flow measured on the freely vibrating model in the wind tunnel was well approximated by the calculated prediction. Author

A90-33373
APPLICATION OF TIME DOMAIN DECOMPOSITION TECHNIQUES TO AIRCRAFT GROUND AND FLUTTER TEST DATA
J. E. COOPER (Royal Aerospace Establishment Farnborough, England) and J. R. WRIGHT (Queen Mary College, London, England) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 235-243. refs
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Time domain modal identification techniques usually employ overspecified solutions which not only require system modes and spurious modes to be distinguished, but also have ill-conditioned formulations. The Eigensystem Realization Algorithm (ERA) and the Eigensystem Realization Algorithm using Data Correlations (ERA/DC) are two methods that include the Singular Value Decomposition (SVD) in their formulations. The SVD allows truncation of the initial model order and also provides a numerically stable method of solution. In this paper both the ERA and ERA/DC techniques are applied to aircraft ground test data. The parameter estimates obtained from the two approaches are compared and the sensitivity of the parameter estimates to variations in user defined parameters examined. In addition, some sample results from using the ERA/DC technique upon stick jerk response data obtained during the BAe146-300 flutter test program are presented. The ERA/DC technique produced estimates as good as, if not better than, the ERA method and was 3-5 times faster. Author

A90-33374#
FLUTTER ANALYSIS FROM AMBIENT RANDOM RESPONSES
A. SCHENK (DLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 245-252. refs

During the testing of a prototype aircraft, flutter prediction is of great importance. Almost all of the presently available experimental methods, regardless of whether they were developed for application in the frequency or in the time domain, employ artificial excitation. The experimental expenses and testing time (both important cost factors) can be reduced if the ambient air turbulence can be used for excitation. A promising approach for the evaluation of structural response due to turbulence is the combined utilization of the Random Decrement Technique (RDT) and the Ibrahim Time Domain Method (ITD). RDT is used as a kind of preprocessor to calculate free decay responses from measured random responses. In a second step ITD is applied to the free decay responses to identify the modal parameters. Post-processing by applying the Modal Assurance Criterion (MAC) allows the correlation of mode shapes from different analysis runs. In this paper the proposed method is applied to an aircraft at three different flight velocities. Author

A90-33380#
WHOLE HELICOPTER AEROELASTICITY - EXPERIENCE WITH A NEW APPROACH
G. T. S. DONE (City University, London, England) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 307-310. refs

A computer program called Automatic Generation of Equations of Motion (AGEM) is discussed. First, the theoretical background is briefly surveyed, noting that deflections on those parts of the helicopter which are contributing to the helicopter aeroelastic model are expressed at an instant of time in terms of modes and generalized coordinates. The computer model is set up in AGEM by means of an input module interrogating the user and receiving the types and order of axis transformation required. One of the verification exercises, concerned with air resonance of a helicopter in forward flight, is outlined, including the effects of fuselage aerodynamics and the autostabilization control system equipment. V.T.

A90-33385#
STRUCTURAL-ACOUSTIC ANALYSIS OF AIRCRAFT FUSELAGE STRUCTURES USING GENERAL PURPOSE FINITE ELEMENT CODES
S. HAEUSLER, C. WENIGWIESER, and I. U. BORCHERS (Dornier Luftfahrt GmbH, Friedrichshafen, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 341-350. refs

The purpose if the study is to show that structural-acoustic analysis can be performed with general-purpose finite element codes by using a displacement-pressure analogy. Relevant parts and basic equations of the analogy between the elasticity equations and the acoustics wave equation are reviewed. A symmetrical finite element formula, based on a modal synthesis methods, is derived. Verification examples are presented with emphasis on fluid-structure coupling effects including eigenfrequency shifts. A practical application of the above finite element method to a full-scale fuselage test section is described. V.T.

A90-33387#
THE INFLUENCE OF MATHEMATICAL OPTIMIZATION METHODS ON THE DESIGN OF AIRCRAFT STRUCTURES
J. SCHWEIGER, A. LOTZE, and O. SENSBURG (MBB GmbH, Munich, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 375-383. refs

The paper deals with mathematical optimization methods integrated into analysis programs designing minimum-weight structures in one calculation. These models are useful when composite materials, allowing modifications of their strength and stiffness properties in optimal combinations, are employed. Rather than running the design process through all of the phases of structural design, it is possible to include those phases in one model. Examples are presented for a preliminary structural design different fighter wings; a wing cover skin design for optimal flap hinge moments; and a structural design of vertical tails for high elastic directional stability and rudder effectiveness in the presence of strength and flutter constraints. It is noted that the above methods simultaneously consider requirements of static strength, dynamic behavior, aeroelasticity, and manufacturing. V.T.

A90-33388#
AEROELASTIC ANALYSIS USING FINITE ELEMENT MODELS
PH. NICOT and C. PETIAU (AMBDA, S.A., Saint-Cloud, France) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 385-397. refs

A methodology for performing loads and aeroelasticity analyses is presented. In order to solve the problem of integration of these calculations on the basis of the finite element method, a computational strategy in which computations are performed in two stages is adopted. In the first stage, finite element and theoretical aerodynamic computations are carried out. The introduction of a load basis and an aerodynamic shape basis allows these computations to be done independently of one another and every parameter variations, as well as model refinements and corrections. In the second stage, the fluid-structure interactions and flight maneuvers are performed. It is only in this stage all the various and specific hypotheses are introduced - empirical corrections based on wind tunnel and/or flight testing experiments, Mach number, altitude, mass distribution, and flight control system philosophy. V.T.

A90-33389#
AEROELASTIC TAILORING VALIDATION BY WINDTUNNEL MODEL TESTING
GUENTER SCHNEIDER, H. HOENLINGER, W. GULDNER, and R. MANSER (MBB GmbH, Munich, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 399-408. refs

Aeroelastic tailoring is a design technique using unidirectional stiffness of composite structures in aircraft structural design to control aeroelastic deformations so that the aerodynamic performance is beneficially affected. Aeroelastic analysis and optimization programs are now well developed for practical application. An example for an optimized fin design fulfilling aeroelastic and flutter requirements is presented. Test results of full-scale prototype structures are not available in the design phase, therefore the development of scaled aeroelastic models is a possibility to overcome this gap. A scaled aeroelastic fin model was designed according to full-scale design with some model limitations. Techniques in fabrication of unbalanced skin laminates were tested and two models with a different skin design were structurally tested. Windtunnel tests at sub- and supersonic Mach numbers were performed, aerodynamic loads and structural deformations were measured. Shortcomings in theoretical methods, tolerances in fabrication, test rigs and measurements must be considered together for the evaluation of aeroelastic model test results. In that way aeroelastic models will be an important step in validation of aeroelastic tailoring principles. Author

A90-33390#
AEROELASTIC ANALYSIS FOR A COMPOSITE T-TAILPLANE OF A TURBOPROP COMMUTER AIRCRAFT
L. LECCE, F. MARULO, P. VITIELLO (Napoli, Universita, Naples, Italy), B. LEONE, and M. PECORA (Aeritalia S.p.A., Pomigliano d'Arco, Italy) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 409-416. refs

The paper presents an aeraoelastic study performed on a composite T-tail, candidate structural configuration for a turboprop commuter aircraft, stretched version of a previous one. The T-tailplane was initially designed and the composite material tailored to meet only the static structural requirements, then its aeroelastic dynamic behavior was investigated, including a detailed failure analysis. The first results showed a critical flutter speed below the FAR requested minimum due to a fin bending-torsion coupling with stabilizer bending-participation, giving reason for next parametric and sensitivity studies. The final structural configuration, obtained by a more proper and efficient design of the fin torsional box, meets both the static and the aeroelastic requirements even maintaining the main benefits of weight and costs savings. Author

A90-33400*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RECENT ACTIVITIES WITHIN THE AEROSERVOELASTICITY BRANCH AT THE NASA LANGLEY RESEARCH CENTER

THOMAS NOLL, BOYD PERRY, III, and MICHAEL GILBERT (NASA, Langley Research Center, Hampton, VA) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 509-517. Previously announced in STAR as N89-24314. refs

The objective of research in aeroservoelasticity at the NASA Langley Research Center is to enhance the modeling, analysis, and multidisciplinary design methodologies for obtaining multifunction digital control systems for application to flexible flight vehicles. Recent accomplishments are discussed, and a status report on current activities within the Aeroservoelasticity Branch is presented. In the area of modeling, improvements to the Minimum-State Method of approximating unsteady aerodynamics are shown to provide precise, low-order aeroservoelastic models for design and simulation activities. Analytical methods based on Matched Filter Theory and Random Process Theory to provide efficient and direct predictions of the critical gust profile and the time-correlated gust loads for linear structural design considerations are also discussed. Two research projects leading towards improved design methodology are summarized. The first program is developing an integrated structure/control design capability based on hierarchical problem decomposition, multilevel optimization and analytical sensitivities. The second program provides procedures for obtaining low-order, robust digital control laws for aeroelastic applications. In terms of methodology validation and application the current activities associated with the Active Flexible Wing project are reviewed. Author

A90-33409#
A REVIEW OF AEROELASTICITY RESEARCH AT THE FLIGHT DYNAMICS LABORATORY
EDMUND PENDLETON, V. JAMES SALLEE, MAX BLAIR, and LAWRENCE HUTTSELL (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 595-604. refs

The primary projects of research in the field of aeroelasticity, which were recently completed or are currently underway at the Flight Dynamics Laboratory of the Wright Research and Development Center, are overviewed. Four major topics are discussed: (1) the aeroservoelasticity of aircraft with multiple input/multiple output; (2) digital flight control systems; (3) the linear-time-domain unsteady, transonic steady, and unsteady aerodynamics; and (4) the design and tests on an advanced aircraft configuration. Tests conducted on a generic fighter configuration with advanced flexible wings and integrated active controls are described. Also described is a recently released computer code designed to analyze an aircraft with a multiple input/multiple output digital control system. I.S.

A90-33412#
REDUCED-ORDER AEROELASTIC MODELS VIA DYNAMIC RESIDUALIZATION
M. KARPEL (Technion - Israel Institute of Technology, Haifa) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 633-642. refs

A dynamic residualization method is described that makes it possible to retain important structural and unsteady aerodynamic effects associated with high-frequency vibration modes without increasing the size of the model used for aeroelastic analysis. The formulation is based on state-space equations of motion, in which the unsteady aerodynamic force coefficients are represented by a minimum-state rational approximation function. A numerical example which employs a realistic aircraft model is presented. Comparisons of the reduced-order model errors with those obtained by mode truncation and by static residualization show that the dynamic residualization yields significantly more accurate models than those obtained by the other reduction techniques. I.S.

A90-33414#
EFFECTS OF TAILPLANE AERODYNAMICS AND FUSELAGE FLEXIBILITY ON THE FLUTTER OF HIGH ASPECT RATIO, LOW SPEED AIRCRAFT
J. R. BANERJEE and A. A. CAL (City University, London, England) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 647-656. refs

The effects of tail-plane aerodynamcs and fuselage flexibility on the symmetric flutter of a high-aspect-ratio low-speed aircraft are investigated. The method follows a normal mode approach through the use of generalized coordinates as given by Banerjee (1984) and Banerjee and Cal (1988). The aircraft is idealized both structurally (by using the beam and lumped mass elements to represent the aircraft) and aerodynamically (by using the strip theory for high-aspect-ratio wings at low speeds). As an example of high-aspect-ratio low-speed aircraft, the sailplane Kestrel-22 m is idealized and is used to obtain the numerical results. I.S.

A90-33707#
AIRBUS A320 CFRP-RUDDER STRUCTURAL REQUIREMENTS
JOERG HOPPE (MBB GmbH, Hamburg, Federal Republic of Germany) IN: Designing with advanced composites; Report on the European Core Conference, 1st, Zurich, Switzerland, Oct. 20, 21, 1988, Conference Papers. Wilmington, DE, DuPont Nomex, 1988, 16 p.

This paper shows the chief facts of the A320 CFRP-rudder design and the most important aspects of its structure mechanics. The lateral sandwich-designed panels of the rudder are presented in detail. The strength justification of a high-loaded, but light-weight sandwich component requires a lot of quality performance from the core and its faces. Author

A90-33709#
CORE COMPOSITES IN SWISSAIR AIRCRAFT
ERNST F. SCHIANTARELI (Swissair, Kloten, Switzerland) IN: Designing with advanced composites; Report on the European Core Conference, 1st, Zurich, Switzerland, Oct. 20, 21, 1988, Conference Papers. Wilmington, DE, DuPont Nomex, 1988, 7 p.

Sandwich core composite structures are finding applications in commercial aircraft cabin interiors, fuselage stabilizers, wing control surfaces, and engine nacelle cowlings. Attention is presently given to the maintenance, inspection and repair process requirements that arise from this more widespread use of honeycomb structural components, with a view to the properties of the more recently developed and fabricated components. Honeycomb structures must be inspected for panel delamination, permanent deformation, fatigue-cracking, and water migration/entrapment in the honeycomb core. O.C.

A90-33714#
STARSHIP - A MODEL FOR FUTURE DESIGNS
EDWIN H. HOOPER (Beech Aircraft Corp., Wichita, KS) IN: Designing with advanced composites; Report on the European Core Conference, 1st, Zurich, Switzerland, Oct. 20, 21, 1988, Conference Papers. Wilmington, DE, DuPont Nomex, 1988, 6 p.

The airframe of the Starship I, an innovative 8-10 passenger, twin-turboprop corporate aircraft, is approximately 72-percent composite; the composites in question are graphite/epoxy laminates and Nomex honeycomb-core sandwich panels. Nomex honeycomb cores may vary in geometry between the widely-used hexagonal-cell type; the rectangular-cell 'ox-core', which facilitated curving or permanent forming in one of the panel directions; and 'flex-core', which allows formation into compound curves without cell-wall buckling. Attention is given to the use of honeycomb core sandwich components in the fuselage and wing structures of Starship I. O.C.

A90-33886
AIAA/SFTE/DGLR/SETP, BIANNUAL FLIGHT TEST CONFERENCE, 5TH, ONTARIO, CA, MAY 22-24, 1990, TECHNICAL PAPERS

Washington, DC, American Institute of Aeronautics and Astronautics, 1990, 468 p. For individual items see A90-33887 to A90-33930.

The present conference discusses topics associated with weapons system testing, unmanned flight vehicle testing, atmospheric flight testing, test measurement techniques, the integration of flight testing and simulation, current test programs, integrated avionics system testing, test safety-related practices, and aircraft testing for high agility. Attention is given to F-16/GPS integration test results, flight testing and numerical analyses of half-scale unmanned air vehicles, the F-15 STOL and maneuver technology demonstrator flights, flow visualization for flight tests, a helmet-mounted display synthetic visibility system, and the 'Digitac' flight-control testbed aircraft. Also discussed are the Tacit Rainbow program, F-15E terrain-following test results, agility considerations for air combat, an expert system for real-time aircraft monitoring, and spin-recovery parachute experience on light aircraft. O.C.

A90-33890#
FLIGHT TEST AND NUMERICAL ANALYSIS OF A HALF-SCALE UNMANNED AIR VEHICLE
R. M. HOWARD, D. E. MEEKS (U.S. Naval Postgraduate School, Monterey, CA), D. F. LYONS (U.S. Navy, Naval Aviation Depot, Cherry Point, NC), and J. C. TANNER IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 27-33. refs
(AIAA PAPER 90-1260)

A 1/2-scale Unmanned Air Vehicle was used to predict the lift and drag characteristics of the full-scale vehicle. Ground tests for power and thrust using a torque stand and a low-speed wind tunnel supported the flight tests for the determination of engine and propeller parameters. A panel method was used to predict the induced drag behavior of the tested air vehicle. Parasite drag was predicted by build-up methods. Parasite drag was underpredicted by 25 percent, and induced drag was overpredicted by 15 percent. However, the flight-test data scatter prevents a conclusive statement on these error estimations. Additional work was carried out to determine if wing drag could be reduced with an improved surface finish and a trailing edge modification. Author

A90-33891*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WIND-TUNNEL AND FLIGHT-TEST INVESTIGATION OF THE EXDRONE REMOTELY PILOTED VEHICLE CONFIGURATION
LONG P. YIP, DAVID J. FRATELLO, DAVID B. ROBELEN (NASA, Langley Research Center, Hampton, VA), and GEORGE M. MAKOWIEC (Vigyan Research Associates, Inc., Hampton, VA) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 34-46. refs
(AIAA PAPER 90-1261) Copyright

At the request of the United States Marine Corps, an exploratory wind-tunnel and flight test investigation was conducted by the NASA Langley Research Center to improve the stability, controllability, and general flight characteristics of the Marine Corps Exdrone RPV (Remotely Piloted Vehicle) configuration. Static wind tunnel tests were conducted to identify and improve the stability and control characteristics of the vehicle. The wind-tunnel test resulted in several configuration modifications which included increased elevator area, increased vertical tail area and moment arm, increased rudder area and aileron area, the addition of vertical wing-tip fins, and the addition of leading-edge droops on the outboard wing panel to improve the stall departure resistance. Flight tests of the modified configuration were conducted at the NASA Plum Tree Test Site to provide a qualitative evaluation of the flight characteristics of the modified configuration. Author

A90-33892#
A CONCEPT STUDY ON THE USE OF REMOTELY PILOTED, SUB-SCALE AIRCRAFT FOR HIGH REYNOLDS NUMBER TESTING
WALTER H. HOWARD, JR. (Boeing Commercial Airplanes, Seattle, WA) and S. M. BATILL (Notre Dame, University, IN) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 47-56. refs
(AIAA PAPER 90-1263) Copyright

The feasibility of using remotely piloted, subscale versions of prospective transport aircraft for in-flight aerodynamic testing at low altitudes and high Reynolds numbers has been investigated, with a view to the proper scaling, the maneuvering flight requirements, the propulsion system simulation, and the structural considerations of RPVs. Attention is given to the results of tests conducted with subsonic and supersonic transport aircraft subscale models. It is concluded on these bases that full-scale Reynolds number information on these aircraft configurations may be limited due to engine size constraints and maneuvering performance limitations. O.C.

A90-33893#
KC-135R LOW ALTITUDE AIR REFUELING FLIGHT TEST PROGRAM
LARRY A. ROBERTS (USAF, Wright-Patterson AFB, OH) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 57-65.
(AIAA PAPER 90-1265)

A flight test program has been conducted to ascertain the effects of the low altitude, 500-3000 ft environment on the operational effectiveness and service life expectancy of refueling tanker aircraft systems and structures, as well as aircrew work-loads. A KC-135R aircraft was extensively instrumented for the 14 test-mission, 70 flight-hour test program, whose primary goal was the demonstration of refueling operations at 1000-ft altitude. During refueling in any amount of turbulence, the duration of contact between tanker and refueling B-52G aircraft was dramatically affected. O.C.

A90-33896#
F-15 STOL AND MANEUVER TECHNOLOGY DEMONSTRATOR FLIGHT TEST PROGRESS REPORT
GREGORY J. RUSBARSKY (McDonnell Aircraft Co., Saint Louis, MO) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 90-100.
(AIAA PAPER 90-1269) Copyright

A flight test program of 100 flights over a 15-month period has been instituted for the USAF's F-15 STOL/Maneuver Technology Demonstrator (S/MTD) aircraft, which was ultimately to incorporate a two-dimensional thrust vectoring/thrust-reversing nozzle system. A four-channel digital fly-by-wire Integrated Flight/Propulsion Control system was used by the S/MTD aircraft which employed both the aerodynamic control surfaces and the engine nozzles as 'control-effectors' throught the flight envelope. Test results are presented for both the axisymmetric nozzle and subsequent two-dimensional nozzle phases of the performance envelope-expansion program. O.C.

A90-33899#
ADVANCED PARAMETER IDENTIFICATION TECHNIQUES FOR NEAR REAL TIME FLIGHT FLUTTER TEST ANALYSIS
A. BUCHARLES (ONERA, Centre d'Etudes et de Recherches de Toulouse, France), H. CASSAN, and J. ROUBERTIER (Aerospatiale, Toulouse, France) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of

Aeronautics and Astronautics, 1990, p. 118-125. refs
(AIAA PAPER 90-1275) Copyright

The necessity to have the A 320 certified only 11 months after first flight has led the Flight Test Department from Aerospatiale and the Automatic Control Department from ONERA/CERT to jointly develop advanced parameter-identification methods for flight flutter test analysis, with the object of reducing the duration of the flutter test program. These methods, which assume a known excitation and work in the frequency domain, automatically provide the flutter specialist with estimated frequency and damping of structural modes from frequency responses handled separately or jointly. This paper gives a description of the procedures used for flutter parameter evaluation, with emphasis on identification algorithms. Their performances are illsutrated from A 320 flight flutter test data. Author

A90-33902#
ADVANCEMENTS IN ROTOR AND AIRFRAME STRUCTURAL FLIGHT TESTING DEVELOPED DURING THE SH-60B G.W./C.G. EXPANSION PROGRAM
J. RICHARD LAMB, BARRY P. W. STOCKER, and KEVIN W. WASHUTA (Sikorsky Aircraft, Stratford, CT) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 170-179.
(Contract N00019-84-G-0203)
(AIAA PAPER 90-1281) Copyright

An expansion program for the gross weight/center of gravity characteristics and the altitude and maneuverability envelopes of the SH-60B helicopter has been conducted on the basis of a structural load-calibrated airframe, control sensitivity testing, and critical altitude qualification testing. These techniques proved capable of yielding information on tail-rotor thrust levels and on stabilator roll and lift moments. The load-calibrated airframe allowed the aircraft to be flown to its actual structural limits, rather than to conservatively defined load-factor and sideslip envelopes. O.C.

A90-33903*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PRELIMINARY FLIGHT TEST INVESTIGATION OF AN AIRBORNE WAKE VORTEX DETECTION CONCEPT
HARRY A. VERSTYNEN (NASA, Langley Research Center, Hampton, VA) and JAMES C. PATTERSON, JR. (Vigyan Research Associates, Inc., Hampton, VA) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 180-186. refs
(AIAA PAPER 90-1282) Copyright

NASA and the FAA have conducted a brief flight-test investigation to furnish preliminary data on the feasibility of transport aircraft wake-vortices' detection, with a view to improving airport capacity by reducing the longitudinal in-trail spacing between aircraft on landing runs. Attention was given to the possibility that the detection of strong vortices at a sufficiently early stage might furnish reasonable warning of impending aerodynamic effects. Preliminary results indicate that while maximum detection distances obtainable with wingtip-mounted flow-angularity vanes are slightly lower than had been predicted, improved detector algorithms may render them more sensitive. O.C.

A90-33904*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FLIGHT-MEASURED STREAMWISE DISTURBANCE INSTABILITIES IN LAMINAR FLOW
CYNTHIA C. LEE (NASA, Langley Research Center, Hampton, VA), CLIFFORD J. OBARA (Lockheed Engineering and Sciences Co., Hampton, VA), and MICHAEL S. WUSK (Analytical Services and Materials, Inc., Hampton, VA) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 187-194. refs
(AIAA PAPER 90-1283) Copyright

NASA is presently conducting laminar-flow flight research to explore the limits of practical applications of laminar-flow drag reduction technology. An important aspect of this research involves studies of the dominant instability or instabilities responsible for initiating the transition process from laminar to turbulent flow. Recent subsonic flight experiments using an instrumented wing glove on a Lear 28/29 airplane measured the growth of the two-dimensional, viscous Tollmien-Schlichting (T-S) instability. The gloved wing section incorporated closely-spaced, flush-mounted, streamwise-located instrumentation for measuring the instability frequencies, surface temperatures, and pressure distributions. Flight conditions of the experiment includeed Mach numbers from 0.70 to 0.79 and chord Reynolds numbers from 10 to 20 million. An onboard engineer's station allowed for real-time analysis of the instability frequency data. In addition to a sample of results on the streamwise growth of instabilities, details of the glove and sensor installation and the onboard real-time data analysis system are given. Author

A90-33905#
IN FLIGHT FLOW ANGLE MEASUREMENTS ON THE BALL-BARTOE JETWING POWERED LIFT AIRCRAFT
U. P. SOLIES (Tennessee, University, Tullahoma) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 195-205. refs
(AIAA PAPER 90-1284) Copyright

Flight tests were conducted with the 'Ball-Bartoe Jetwing' powered lift technology demonstration aircraft to visualize flow angles on the fuselage surface and at selected points in the flow field near the horizontal tail. Simple data acquisition techniques were used. The results clearly indicate the downwash near the horizontal tail and its variation with airspeed, jet deflection angle, and blowing coefficient over a range of level flight conditions. Further research is needed to broaden the data base and substantiate these findings. Author

A90-33909#
THE USE OF SIMULATION IN SUPPORT OF THE HIGH AOA FLIGHT TEST PROGRAM OF THE AM-X AIRCRAFT
P. CHIMETTO, U. GIANCHECCHI, M. LUCCHESINI, and E. VALTORTA (Aermacchi S.p.A., Varese, Italy) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 233-247.
(AIAA PAPER 90-1289) Copyright

The paper reports the main results and advantages obtained with the use of simulation tools during the high AOA tests of the AM-X aircraft, and highlights the decisive importance simulation had in the prediction of the aircraft behavior during test planning, flight testing, and correlating predictions and flight tests. The results show that the use of simulation tools permitted the program objectives to be achieved at enhanced cost-effectivenes and flight-test safety. Author

A90-33912#
EH 101 FLIGHT TEST PROGRAM CURRENT STATUS AND FUTURE TESTING
B. PAGGI (Agusta S.p.A., Cascina Costa, Italy) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 262-270.
(AIAA PAPER 90-1296) Copyright

This paper gives an overview of EH 101 Flight Test Program, providing an updating of the development program. The climatic trials program scheduled in order to achieve the qualification/certification is presented. The major problems encountered during development carried out so far are shown, with relative solutions adopted or that are under assessment. Author

A90-33920*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A FLIGHT TEST INVESTIGATION OF CERTIFICATION REQUIREMENTS FOR LAMINAR-FLOW GENERAL AVIATION AIRPLANES
GREGORY S. MANUEL (NASA, Langley Research Center, Hampton, VA) and WAYNE A. DOTY (Cessna Aircraft Co., Wichita, KS) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 337-344. refs
(AIAA PAPER 90-1310) Copyright

A modified T210R general aviation aircraft incorporating natural laminar flow (NLF) technology has been subjected to flight tests in order to evaluate its stability and control characteristics. Attention is given to this aircraft's ability to meet certification requirements with significant NLF, as well as with the boundary-layer transition fixed near the leading edge. It is established that the large regions of NLF achieved yielded a significant cruise performance enhancement; loss of laminar flow did not result in significant changes in the stability and control characteristics of the aircraft. FAR Part 23 certification requirements were met. O.C.

A90-34028
BOEING CONDOR RAISES UAV PERFORMANCE LEVELS
BRECK W. HENDERSON Aviation Week and Space Technology (ISSN 0005-2175), vol. 132, April 23, 1990, p. 36-38.
Copyright

The Condor unmanned aerial vehicle (UAV) demonstrated significant altitude and endurance capabilities during its recently completed flight test program, but the aircraft faces an uncertain future unless a customer is found. Lightweight composite structure and autonomous controls with efficient aerodynamic design and a propulsion system with excellent fuel economy have been combined to create an unmanned aircraft capable of operating above 65,000 ft for several days. At that altitude, Condor has a long line of sight for optical or radar sensors, is well above weather and commercial transport traffic and is in a zone of relatively calm winds. However, with a large radar signature and slow cruise speed, it is vulnerable to antiaircraft weapons. It is powered by two six-cylinder, 175-hp liquid cooled engines with two stages of turbo-charging to maintain engine efficiency at high altitude.
R.E.P.

A90-34148#
FLOW VISUALIZATION IN FLIGHT TESTING
JAMES P. CROWDER (Boeing Commercial Airplanes, Seattle, WA) AIAA, SFTE, DGLR, and SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990. 14 p. refs
(AIAA PAPER 90-1273) Copyright

The utility of flow visualization techniques applied to inflight airplane testing is reviewed for detecting separation, shock waves, and boundary layer transition, and for the measurement of surface pressure and flow field details. Methods for each of these applications are described, and recent inflight or wind tunnel examples are presented. Author

A90-34360
HIGHER HARMONIC CONTROL OF A HELICOPTER MODEL ROTOR TO REDUCE BLADE/VORTEX INTERACTION NOISE
W. R. SPLETTSTOESSER (DLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany), G. LEHMANN, and B. VAN DER WALL (DLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 14, no. 1-2, 1990, p. 109-116. refs
Copyright

Initial acoustic results are presented from a higher-harmonic control (HHC) wind-tunnel pilot experiment on helicopter-rotor blade/vortex interaction (BVI) impulsive noise reduction, making use of the DLR 40-percent scale BO-105 research rotor in the DNW 6 x 8-m closed test section. Considerable noise reduction (of several dB) has been measured for particular HHC settings, but at the cost of increased vibration levels and vice versa. The apparently adverse results for noise and vibration reduction by HCC are explained. At optimum pitch control settings for BVI noise reduction, rotor-simulation results demonstrate that blade loading at the outer tip region is decreased and vortex strength and blade/vortex separation-distance are increased, resulting overall in reduced BVI noise generation. At optimum pitch control settings for vibration reduction, there are adverse effects on blade loading, vortex strength, and blade/vortex separation distance. Further investigations into the validation and optimization of the HHC potential for rotor noise and vibration reduction are recommended. Author

A90-34581
OPTICAL WINDOW MATERIALS FOR HYPERSONIC FLOW
ROBERT H. AU (Lockheed Missiles and Space Co., Inc., Astronautics Div., Sunnyvale, CA) IN: Window and dome technologies and materials; Proceedings of the Meeting, Orlando, FL, Mar. 27-29, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 330-339. refs
Copyright

Optical window materials were investigated for infrared sensor systems used in observing ground targets from a hypersonic-glide vehicle. The equilibrium temperature of the window in the glide region depends on the emissivity and varied between 1,370 and 2,250 K. The high temperatures showed that a protective cover over the window is required during the entire glide region of the trajectory. Ejection of the window cover at 70-kft altitude in the terminal region was assumed, resulting in maximum window temperatures of 565 K and 592 K for magnesium oxide and diamond windows, respectively, both 0.8-in thick. The window temperatures for germanium and sapphire were also calculated. Thermal shock, thermal expansion, the effects of the window radiation on the infrared detectors and methods to reduce the hot window problem were examined. Author

A90-34725*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE VORTEX FLAP F-106B, OVERCOMING SAFETY AND DATA PROBLEMS IN FLIGHT TESTING
PHILIP W. BROWN (NASA, Langley Research Center, Hampton, VA) AIAA, SFTE, DGLR, and SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990. 9 p. refs
(AIAA PAPER 90-1280) Copyright

A NASA, F-106B airplane equipped with a vortex flap is establishing a data base for calibration of design and analysis tools for this vortical flow control concept. Some of the problems in safely and precisely flying to research data points were caused by the modified airplane's low longitudinal stability and low margin of structural strength. These characteristics are, in part, a consequence of the program's low cost approach which utilizes a bolt-on, ground-adjustable flap attached to a minimally modified airplane. Presently, the 40-degree flap deflection flight research is being concluded with a flow visualization phase. A similar pattern of flight envelope expansion, pressure distribution, performance, and flow visualization phases remain to be accomplished for the 30-degree flap setting. To date, good research flight data has followed resolution of the safety and data problems described.
Author

A90-34740* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ANALYSIS OF AIRCRAFT TIRES VIA SEMIANALYTIC FINITE ELEMENTS
AHMED K. NOOR, KYUN O. KIM, and JOHN A. TANNER (NASA, Langley Research Center; George Washington University, Hampton, VA) Finite Elements in Analysis and Design (ISSN 0168-874X), vol. 6, March 1990, p. 217-233. refs
(Contract NAG1-852)
Copyright

A computational procedure is presented for the geometrically nonlinear analysis of aircraft tires. The tire was modeled by using a two-dimensional laminated anisotropic shell theory with the

effects of variation in material and geometric parameters included. The four key elements of the procedure are: (1) semianalytic finite elements in which the shell variables are represented by Fourier series in the circumferential direction and piecewise polynomials in the meridional direction; (2) a mixed formulation with the fundamental unknowns consisting of strain parameters, stress-resultant parameters, and generalized displacements; (3) multilevel operator splitting to effect successive simplifications, and to uncouple the equations associated with different Fourier harmonics; and (4) multilevel iterative procedures and reduction techniques to generate the response of the shell. Author

A90-34900
V-22 - THE PROSPECTS NOW
STANLEY W. KANDEBO Aviation Week and Space Technology (ISSN 0005-2175), vol. 132, May 7, 1990, p. 44, 45, 49 (3 ff.).
Copyright

The anticipated battle to obtain V-22 production funds in the 1991 fiscal year, the status of aircraft flight testing and the evolving issues surrounding the development of commercial tilt-rotors are examined. Prospects for production funding are currently focused on comparative operational and financial cost of the V-22 versus that of modified H-60/CH-53E helicopter fleets. The aircraft's effectiveness are compared for special forces, drug interdiction, antisubmarine warfare and combat search and rescue missions, as well as amphibious assault. V-22 flight test operations began late last year and over the last four months the aircraft has flown more than 15 hours. A second aircraft is expected to join the test program to develop the aircraft's automatic flight control system. R.E.P.

A90-34968
A MODERN COURSE IN AEROELASTICITY /2ND REVISED AND ENLARGED EDITION/
EARL H. DOWELL (Duke University, Durham, NC), HOWARD C. CURTISS, JR. (Princeton University, NJ), ROBERT H. SCANLAN (Johns Hopkins University, Baltimore, MD), and FERNANDO SISTO (Stevens Institute of Technology, Hoboken, NJ) Dordrecht, Kluwer Academic Publishers, 1989, 576 p. refs
Copyright

The fundamental principles of aeroelastic analysis and design are discussed in an introductory textbook for engineering students. Topics addressed include static and dynamic aeroelasticity, the unsteady aerodynamics of lifting and nonlifting surfaces, stall flutter, aeroelastic problems of civil-engineering structures, rotorcraft problems, aeroelasticity in turbomachines, and unsteady transonic aerodynamics and aeroelasticity. Diagrams, graphs, and a set of sample problems are provided. T.K.

N90-20056# Laboratoire de Medecine Aerospatiale, Bretigny-sur-Orge (France).
PARACHUTE OPENING SHOCKS DURING HIGH SPEED EJECTIONS: NORMALIZATION [CHOCS A L'OUVERTURE LORS DES EJECTIONS A GRANDE VITESSE? QUELLES NORMES?]
A. LEGER, P. DOLOU, P. SANDOR, and P. BEAUDOUIN (Service Technique des Programmes Aeronautiques, Paris, France) *In* AGARD, Implications of Advanced Technologies for Air and Spacecraft Escape 7 p Feb. 1990 In FRENCH
Copyright Avail: NTIS HC A06/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Conditions which evolve during combat flight leads to the consideration of the probability of pilot ejection at low altitude high speed flight. Problems associated with wind blast and the stability of the ejection seat could lead to the risk of injury connected to parachute opening. A study demonstrating the compatibility of the MK 10 seat ejection with different combat aircraft was carried out by testing on a dynamic rail. The results show a significant increase in recorded G(z) acceleration during the opening of the main parachute. A biomechanical analysis of the shocks shows the role played by different phases during the opening. These data are given so that the normalization problem and useful criteria can be considered. Author

N90-20070 Maryland Univ., College Park.
AEROELASTIC CHARACTERISTICS OF AIRCRAFT WITH CIRCULATION CONTROL WINGS Ph.D. Thesis
DAVID JOSEPH HAAS 1989 159 p
Avail: Univ. Microfilms Order No. DA8924160

The aeroelastic characteristics of high aspect ratio circulation control (CC) wings cantilevered at the root and attached to a free flying aircraft are investigated. Several analytical models are developed with varying degree of complexity. First, a cantilevered CC wing is examined. Static divergence and a circulation control reversal phenomenon are investigated through the use of lift and control effectiveness ratios. The flutter instability is analyzed using an elastic beam model in conjunction with a modified strip analysis method based on classical unsteady airfoil theory. Then, aeroelastic stability of a free flying aircraft with rigid body pitch and plunge motions is examined using the finite element method. For this, unsteady aerodynamic loads are calculated using a time domain, unsteady aerodynamic model based on the indicial response method. Steady experimental circulation control airfoil data are used to determine the airfoil lift curve slope and aerodynamic center location as a function of angle of attack, blowing level, and Mach number. The effects of several design parameters on aeroelastic stability are examined including; wing sweep angle, elastic axis location, wing torsion and bending stiffness, fuselage inertia, blowing level, and span-wise blowing distribution. Loss of control effectiveness was found to be critical on the aft-swept wing. A low speed flutter instability, unique to wings employing circulation control blowing, was identified. Dissert. Abstr.

N90-20071*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE APPLICATION OF ACTIVE CONTROLS TECHNOLOGY TO A GENERIC HYPERSONIC AIRCRAFT CONFIGURATION
M. G. GILBERT, J. HEEG, A. S. POTOTZKY, C. V. SPAIN, D. L. SOISTMANN (Lockheed Engineering and Sciences Co., Hampton, VA.), and H. J. DUNN Jan. 1990 16 p Presented at the 7th National Aero-Space Plane Technology Symposium, Cleveland, OH, Oct. 1989
(NASA-TM-101689; NAS 1.15:101689) Avail: NTIS HC A03/MF A01 CSCL 01/3

Analytical methods are described for the prediction of aerothermoelastic stability of hypersonic aircraft including active control systems. Thermal loads due to aerodynamic heating were applied to the finite element model of the aircraft structure and the thermal effects on flutter were determined. An iterative static aeroelastic trim analysis procedure was developed including thermal effects. And active control technology was assessed for flutter suppression, ride quality improvement, and gust load alleviation to overcome any potential adverse aeroelastic stability or response problems due to aerodynamic heating. A generic hypersonic aircraft configuration was selected which incorporates wing flaps, ailerons, and all moveable fins to be used for active control purposes. The active control system would use onboard sensors in a feedback loop through the aircraft flight control computers to move the surfaces for improved structural dynamic response as the aircraft encounters atmospheric turbulence. Author

N90-20072# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
FLOOR PULL TEST OF A TRANSPORT AIRFRAME SECTION
DICK JOHNSON and ANTHONY WILSON Dec. 1989 71 p
(DOT/FAA/CT-TN88/14) Avail: NTIS HC A04/MF A01

An 8-foot length of a transport airplane airframe and cabin floor structure, located at the Federal Aviation Administration Technical Center, was statically pull tested to failure. Two tests were conducted and consisted of vertically loading the floor structure in an upward direction at both the four and two intersecting seat track/floor beam locations, respectively. This test procedure was used to simulate the magnitude and direction of external

loads that could be applied to the floor track by an aft seat leg fitting during a longitudinal impact occurrence. Floor load, deflection, and strain data were obtained for each of the two loading conditions. The first test, which involved the uniform loading of a center position floor beam and related floor track structure at four track locations (body station 540), resulted in the failure of track and floor beam under a maximum beam failure load of 21,859 pounds. The second test condition, involving a subsequent loading of the same beam but at only two track locations (with the remaining half of beam restrained), resulted in track failure at a maximum load of 14,169 pounds. These failure loads were within 20 percent of those identified under a prior analytical analysis of the fuselage/floor structure. Dissert. Abstr.

N90-20073# *Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.*
F-15B HIGH ANGLE-OF-ATTACK PHENOMENA AND SPIN PREDICTION USING BIFURCATION ANALYSIS M.S. Thesis
DANIEL D. BAUMANN Dec. 1989 143 p
(AD-A217366; AFIT/GAE/ENY/89D-01) Avail: NTIS HC A07/MF A01 CSCL 01/1

Modern fighter aircraft are being designed to be operated at higher and higher angles-of-attack. The resulting increase in maneuverability is offset however by an increase in susceptibility to departure from controlled flight. An investigation of the F-15B fighter aircraft was undertaken to predict high angle-of-attack phenomena such as flat spins. Aerodynamic forces and moments as a function of control surface deflections were modeled over a wide angle-of-attack range (-20 deg less than or equal to alpha less than or equal to +90 deg) and were then used to formulate a non-linear eight state (alpha, beta, p, q, r, Theta, Psi, V) aircraft model. Equilibrium and periodic solutions to the resulting equations of motion were then computed using a bifurcation analysis package. A number of bifurcation points, limit points and Hopf bifurcation points were detected indicating changes in flight stability. Several stable equilibrium solution branches at angles-of-attack greater than 70 degrees were observed which correspond to flat spin behavior. Theoretically predicted flat spin conditions correlated well with empirical flight test data. In addition stable equilibrium and periodic surveyed resulting in a global map of stability as a function of control surface deflection for the F-15B. GRA

N90-20074# Oklahoma Univ., Norman.
HYPERSONIC WAVERIDER CONFIGURATIONS FOR TRANS-ATMOSPHERIC VEHICLES M.S. Thesis
WILLIAM P. MARTIN 1989 197 p Sponsored by AFIT, Wright-Patterson AFB, OH
(AD-A217925; AFIT/CI/CIA-89-105) Avail: NTIS HC A09/MF A02 CSCL 01/3

The development of a catalogue of waverider shapes generated from axisymmetric conical flow is described. A simple but reliable method of calculating the viscous drag is presented and over one-hundred configurations are shown with various aerodynamic and pertinent geometric design factors. All of the configurations presented are based on Mach number of 10 and Reynolds number (based on the length of the waverider) of 10 to the 6th power. However, the analysis presented adapts itself to any Mach or Reynolds number. The lift-to-drag ratios presented range from 4.32 to 5.06 while the average skin friction coefficient ranged from 0.00176 to 0.00205. The volume to area ratio V2/3/S(p) ranged from 0.224 to 0.153. GRA

N90-20075# Texas A&M Univ., College Station.
A VIDEO-BASED EXPERIMENTAL INVESTIGATION OF WING ROCK Ph.D. Thesis
STEVEN LYNN MORRIS 1989 261 p
(Contract F49620-87-C-0069)
(AD-A218244; AD-E501191; AFIT/CI/CIA-89-148) Avail: NTIS HC A12/MF A02 CSCL 01/1

This research developed a definitive theory on the cause of wing rock. The study was based on dynamic measurements in both a water tunnel and a wind tunnel on a sharp edged delta wing with an 80 deg. leading edge sweep angle. Experimental data were compared with analytical results from a mathematical model and a fourth order Runge-Kutta integration. In the water tunnel tests, conducted at alpha = 35 deg. and Reynolds numbers from 30000/ft to 75000/ft, the movement of the leading edge vortices and the model motion were simultaneously tracked and analyzed using a video-based motion analysis system, ExpertVision. ExpertVision accuracy was validated using stationary and forced oscillation tests on 70 and 80 deg. delta wings. Vortex trajectory, core velocity, and burst point results from stationary tests were in good agreement with published data. Forced oscillation tests proved that ExpertVision could simultaneously track and analyze the movement of leading edge vortices and model motion. Wing rock is caused by the dynamic behavior of the leading edge vortices. The alternate lift-off and reattachment of the vortices generate an asymmetry in vortex lift and cause changes in rolling moment that initiate and sustain roll oscillations. Wing rock dynamics were significantly different water tunnel and wind tunnel experiments. Apparent mass terms must be included in the equations of motion when converting water tunnel acceleration data to rolling moment coefficients. GRA

N90-20076# Army Aviation Engineering Flight Activity, Edwards AFB, CA.
AIRWORTHINESS AND FLIGHT CHARACTERISTICS EVALUATION OF THE MCDONNELL DOUGLAS HELICOPTER CORPORATION (MDHC) 530FF HELICOPTER Final Report, Aug. 1987 - Sep. 1988
JAMES L. WEBRE, WILLIAM Y. ABBOTT, MICHAEL WHITE, WILLIAM STORMER, and WARREN GOULD May 1989 299 p Sponsored by Army Aviation Systems Command, Saint Louis, MO
(AD-A218253; USAAEFA-86-15) Avail: NTIS HC A13/MF A02 CSCL 01/3

An Airworthiness and Flight Characteristics Evaluation of the McDonnell Douglas 530FF helicopter (also known as the AH-6G or MH-6H) was performed. The test consumed 94 productive flight test hours in 152 total hours. Many configurations were flown at gross weights up to 3950 pounds. Three deficiencies related to the handling qualities, and one related to the inability to observe a sideslip/tail rotor flapping limit were identified. Twelve shortcomings were also identified. GRA

N90-20077# Naval Postgraduate School, Monterey, CA.
AERODYNAMIC ANALYSIS OF A US NAVY AND MARINE CORPS UNMANNED AIR VEHICLE M.S. Thesis
DANIEL F. LYONS Jun. 1989 204 p
(AD-A218282) Avail: NTIS HC A10/MF A02 CSCL 01/3

An aerodynamic analysis was performed on a U.S. Navy and Marine Corps Unmanned Air Vehicle (UAV) called PIONEER. A low-order panel method called PMARC (Panel Method Ames Research Center) was used to obtain various aerodynamic parameters and to evaluate the longitudinal and directional stability and control of the vehicle. In addition, a drag analysis of the vehicle was performed using techniques described in Fluid Dynamic Drag by Hoerner. Drag reduction methods were also investigated. The neutral point of the large tail PIONEER was calculated to be at 74 percent of the mean aerodynamic chord (MAC). The small tail neutral point was calculated to be at the 51 percent MAC position. Cross wind limitations were obtained for PIONEER. The maximum sideslip angles due to cross wind were determined to be 8.5 and 18. For an approach speed of 65 knots, cross wind limits were calculated to be ten knots and 22 knots for the single rubber and dual rudder cases, respectively. Drag polars were plotted for PIONEER. It was determined that drag on the vehicle could be reduced by 29 percent using simple and cost effective modifications to the vehicle. Follow-on analysis of PIONEER through the Naval Postgraduate School UAV Flight Test Research Program and through full-scale wind tunnel testing at the National Full-Scale Aerodynamics Complex were also discussed. GRA

N90-20078* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPRESSION PYLON Patent
JAMES C. PATTERSON, JR., inventor (to NASA) 19 Sep. 1989

10 p Filed 23 Jun. 1988
(NASA-CASE-LAR-13777-1; US-PATENT-4,867,394; US-PATENT-APPL-SN-210480; US-PATENT-CLASS-244-54; US-PATENT-CLASS-244-55; US-PATENT-CLASS-244-130)
Avail: US Patent and Trademark Office CSCL 01/3

A compression pylon for an aircraft with a wing-mounted engine, that does not cause supersonic airflow to occur within the fuselage-wing-pylon-nacelle channel is presented. The chord length of the pylon is greater than the local chord length of the wing to which it is attached. The maximum thickness of the pylon occurs at a point corresponding to the local trailing edge of the wing. As a result, the airflow through the channel never reaches supersonic velocities.

Official Gazette of the U.S. Patent and Trademark Office

N90-20079* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

PASSIVE VENTING TECHNIQUE FOR SHALLOW CAVITIES Patent

ROBERT L. STALLINGS, JR., inventor (to NASA) and FLOYD J. WILCOX, JR., inventor (to NASA) 30 Sep. 1988 5 p Filed 30 Sep. 1988
(NASA-CASE-LAR-14031-1; US-PATENT-4,863,118; US-PATENT-APPL-SN-252081; US-PATENT-CLASS-244-130; US-PATENT-CLASS-244-137.4) Avail: US Patent and Trademark Office CSCL 01/3

A device is introduced for reducing drag and store separation difficulties caused by shallow cavities on aircraft in supersonic flight consisting of a group of hollow pipes the same length as the cavity. The pipes are attached to the cavity floor so as to allow air to flow through the pipes. This device allows air to flow through the pipes opposite to the direction of flow outside the pipes. This results in reduced drag and improved store separation characteristics.

Official Gazette of the U.S. Patent and Trademark Office

N90-20971*# Notre Dame Univ., IN. Dept. of Aerospace and Mechanical Engineering.

THE MANTA: AN RPV DESIGN TO INVESTIGATE FORCES AND MOMENTS ON A LIFTING SURFACE Final Design Proposal

KEVIN BRYAN, JOHN SOUTAR, PETER WITTY, BRUNO MEDIATE, THOMAS QUAST, DAN COMBS, MARTIN SCHUBERT, DAVID CONDRON, SCOTT TAYLOR, ED GARINO et al. 1989 91 p
(Contract NASW-4435)
(NASA-CR-186227; NAS 1.26:186227) Avail: NTIS HC A05/MF A01 CSCL 01/3

The overall goal was to investigate and exploit the advantages of using remotely powered vehicles (RPV's) for in-flight data collection at low Reynold's numbers. The data to be collected is on actual flight loads for any type of rectangular or tapered airfoil section, including vertical and horizontal stabilizers. The data will be on a test specimen using a force-balance system which is located forward of the aircraft to insure an undisturbed air flow over the test section. The collected data of the lift, drag and moment of the test specimen is to be radioed to a grand receiver, thus providing real-time data acquisition. The design of the mission profile and the selection of the instrumentation to satisfy aerodynamic requirements are studied and tested. A half-size demonstrator was constructed and flown to test the flight worthiness of the system. Author

N90-20972# Royal Aircraft Establishment, Farnborough (England).

THE ROLE OF STRUCTURAL ANALYSIS IN AIRWORTHINESS CERTIFICATION

P. BARTHOLOMEW Apr. 1989 21 p
(BR112064; RAE-TM-MS-1129) Copyright Avail: NTIS HC A03/MF A01

Those uses of structural analysis which have a bearing on airworthiness are reviewed. In particular the extent to which finite element analysis is already implicitly relied on in the context of clearance by test is considered, and factors which may be expected to lead to an increased reliance are discussed. One such factor is the increased use of the computer aided engineering (CAE) approach which changes the design process itself. An assessment is made of actions required to ensure that results of analysis provide a consistent and reliable basis for airworthiness judgement. Author

N90-20973# Royal Aircraft Establishment, Farnborough (England).

COMPUTER-AIDED STRUCTURAL OPTIMISATION OF AIRCRAFT STRUCTURES

P. BARTHOLOMEW and H. WELLEN Sep. 1989 19 p
(BR112837; RAE-TM-MAT-STR-1138) Copyright Avail: NTIS HC A03/MF A01

The principal methods used within the computer program STARS for the computer-aided design of optimum structures subject to a variety of contraints are described. Based on the foundations set forth regarding both structural and optimization aspects, a description is given of the Newton method as applied in STARS. Likewise, the shape optimization developed in the form of a hierarchical approach is described. Test problems connected with this are presented. Practical examples are given that show how research originated at RAE has been continued and applied at MBB. This includes various components which are typical in aircraft construction and also a description of the manner in which flutter optimization is being accomplished with STARS at MBB in combination with the in-house aeroelastic program. Author

N90-20974*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

PERFORMANCE DATA FROM A WIND-TUNNEL TEST OF TWO MAIN-ROTOR BLADE DESIGNS FOR A UTILITY-CLASS HELICOPTER

JEFFREY D. SINGLETON, WILLIAM T. YEAGER, JR., and MATTHEW L. WILBUR Washington Jun. 1990 82 p Prepared in cooperation with Army Aviation Systems Command, Hampton, VA
(NASA-TM-4183; L-16736; NAS 1.15:4183; AVSCOM-TM-90-B-004) Avail: NTIS HC A05/MF A01 CSCL 01/3

An investigation was conducted in the NASA Langley Transonic Dynamics Tunnel to evaluate an advanced main rotor designed for use on a utility class helicopter, specifically the U.S. Army UH-60A Blackhawk. This rotor design incorporated advanced twist, airfoil cross sections, and geometric planform. For evaluation purposes, the current UH-60A main rotor was also tested and is referred to as the baseline blade set. A total of four blade sets were tested. One set of both the baseline and the advanced rotors were dynamically scaled to represent a full scale helicopter rotor blade design. The remaining advanced and baseline blade sets were not dynamically scaled so as to isolate the effects of structural elasticity. The investigation was conducted in hover and at rotor advance ratios ranging from 0.15 to 0.4 at a range of nominal test medium densities from 0.00238 to 0.009 slugs/cu ft. This range of densities, coupled with varying rotor lift and propulsive force, allowed for the simulation of several vehicle gross weight and density altitude combinations. Performance data are presented for all blade sets without analysis; however, cross referencing of data with flight condition may be useful to the analyst for validating aeroelastic theories and design methodologies as well as for evaluating advanced design parameters. Author

N90-20975# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.

DESIGN OF A NATURAL LAMINAR FLOW AIRFOIL FOR AN UNMANNED AIRCRAFT

K. R. SRILATHA and P. RAMAMOORTHY Mar. 1990 9 p
(PD-CF-9004) Avail: NTIS HC A02/MF A01

A 12 percent thick natural laminar flow (NLF) airfoil is designed for an unmanned aircraft for reconnaissance and target acquisition roles. This airfoil is compared with NACA 64, -612 airfoil of same thickness. NAL airfoil, designated as NAL-NLF-120, has given better

performance than NACA airfoil at the design conditions. For that matter in the entire range 0.4 less than or = C sub L less than or = 0.8 NAL airfoil performs better than the NACA airfoil.
Author

N90-20976# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
COMPUTATIONAL METHODS FOR AERODYNAMIC DESIGN (INVERSE) AND OPTIMIZATION
Mar. 1990 331 p In ENGLISH and FRENCH Meeting held in Loen, Norway, 22-23 May 1989
(AGARD-CP-463; ISBN-92-835-0542-5) Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Computational Fluid Dynamics (CFD) play an increasingly important role in the aerodynamic design of flight vehicles. The main reasons for this are the rapid developments in computer hardware and solution algorithms in combination with the increasing requirements (and potential) for improving aerodynamic quality and reducing design cycle time and cost. This meeting focused on those CFD-based methods which address the problem of design for given aerodynamic characteristics in a direct sense. Examples are inverse methods which provide the detailed geometry required to generate a given pressure distribution and methods utilizing numerical optimization techniques to obtain the geometry that minimizes, subject to constraints, a given aerodynamic objective function.

N90-20978# Aircraft Research Association Ltd., Bedford (England).
AEROFOIL DESIGN TECHNIQUES
A. J. BOCCI *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 18 p Mar. 1990 Sponsored in part by Procurement Executive, Ministry of Defence; British Aerospace Aircraft Group, Hatfield, England; Dowty Rotol Ltd.; and Dept. of Trade and Industry
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Various airfoil design exercises carried out at ARA over the years are described, concentrating on the part played by the inverse methods. The design of an airfoil suitable for the wing of a combat aircraft research model was successful in meeting a number of performance requirements but the inverse supercritical method used gave an unsatisfactory intermediate profile and off-design calculations were necessary to resolve the problem. In a research exercise involving the design of an airfoil suitable for the wing of a transport aircraft to take advantage of full-scale Reynolds number, the inverse supercritical method used produced changes to the geometry in an opposite sense to those finally required. It is suggested that the difficulties with the inverse supercritical methods arose because appropriate design target pressures were not known and because viscous effects were not included in the methods. Subsequent designs of laminar flow airfoils and high-speed propeller blade airfoils are described. For these cases, a technique was used involving a subcritical method, with progressive adjustment of target pressures until a geometry arose with suitable flow development according to a viscous supercritical method, with little use of supercritical inverse methods. Author

N90-20979# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Inst. fuer Entwurfsaerodynamik.
AERODYNAMIC DESIGN TECHNIQUES AT DLR INSTITUTE FOR DESIGN AERODYNAMICS
H. KOESTER, C.-H. ROHARDT, K.-H. HORSTMANN, and R. RADESPIEL *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 15 p Mar. 1990
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Some general remarks about aerodynamic design are given first. Then, a short survey of the design methods used here including the basic ideas and, particularly, an improvement of the design method of McFadden for supercritical airfoils are presented. Also, an overview is given of the analysis methods in use at the DLR institute for design aerodynamics. Design procedures, which use the forementioned design and analysis methods, are explained in detail. With these procedures, several designs of airfoils and nacelles were performed. Results of selected design examples are discussed. Author

N90-20980# Grumman Aerospace Corp., Bethpage, NY.
INVERSE DESIGN OF AIRFOIL CONTOURS: CONSTRAINTS, NUMERICAL METHOD, AND APPLICATIONS
G. VOLPE *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 18 p Mar. 1990
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The classical problem of constructing an airfoil profile that corresponds to an arbitrarily prescribed speed distribution is discussed and recast in a form suitable for transonic applications. The problem, in general, is not well posed unless the specified speed distribution satisfies certain constraints. Thus, a solution exists only if the speed distribution contains a sufficient number of free parameters with values that can be adjusted in order to satisfy the constraints. The nature of the constraints are discussed and several strategies proposed for introducing the necessary freedom in the speed distribution. The computational method described determines the values of the parameters as part of the solution. It is based on the numerical solution of the full potential equation in conservation form with Dirichlet-type boundary conditions by a multigrid-ADI scheme. The general applicability and the accuracy of the numerical method are illustrated by several examples. Author

N90-20981# Textron Bell Helicopter, Fort Worth, TX.
AN EFFICIENT AIRFOIL DESIGN METHOD USING THE NAVIER-STOKES EQUATIONS
J. B. MALONE, J. C. NARRAMORE, and L. N. SANKAR (Georgia Inst. of Tech., Atlanta.) *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 18 p Mar. 1990
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An airfoil design procedure is described that was incorporated into an existing 2-D Navier-Stokes airfoil analysis method. The resulting design method, an iterative procedure based on a residual-correction algorithm, permits the automated design of airfoil sections with prescribed surface pressure distributions. The inverse design method and the technique used to specify target pressure distributions are described. It presents several example problems to demonstrate application of the design procedure. It shows that this inverse design method develops useful airfoil configurations with a reasonable expenditure of computer resources. Author

N90-20982# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Dept. of Theoretical Aerodynamic.
AN INTENSIVE PROCEDURE FOR THE DESIGN OF PRESSURE-SPECIFIED THREE-DIMENSIONAL CONFIGURATIONS AT SUBSONIC AND SUPERSONIC SPEEDS BY MEANS OF A HIGHER-ORDER PANEL METHOD
L. FORNASIER *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 10 p Mar. 1990 (Contract T/RF-41/E0010/E14)
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An advanced panel method employing singularity distributions of higher order and based on mixed boundary conditions of Dirichlet- and Neumann-type was recently developed for the potential flow analysis of arbitrary airplane configurations at subsonic and supersonic speeds. Some work is in progress to provide this method with a design option capable of relofting the surface of a given configuration from prescribed pressure

distributions. The purpose is to present the mathematical background of the inverse algorithm and to account on some examples of application. Author

N90-20983# National Aerospace Lab., Amsterdam (Netherlands).
A SYSTEM FOR TRANSONIC WING DESIGN WITH GEOMETRIC CONSTRAINTS BASED ON AN INVERSE METHOD
F. J. BRANDSMA and J. M. J. FRAY *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 9 p Mar. 1990
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A new system was described for transonic wing design with prescribed pressure distribution in the presence of a fixed body. The residual correction method, on which the design system is based, combines a complex direct flow solver with simple correction rules (inverse supersonic wavy-wall plus inverse 3-D panel method). It is possible to define geometric constraints for the wing to be designed, which is an essential part of the method. Weight factors on the pressure defect corrections and on the corrections associated with the geometric constraints can be adjusted during the iteration process, allowing a maximal control over the design procedure, in order to reach the design goals in the best possible way. The practical applicability of the transonic wing design system was demonstrated by an example. Author

N90-20984# Politecnico di Milano (Italy). Dipartimento di Ingegneria Aerospaziale.
A FAST COLLOCATION METHOD FOR TRANSONIC AIRFOIL DESIGN
SERGIO DEPONTE, MAURIZIO BOFFADOSSI, and CLAUDIO MANTEGAZZA (Aeronautica Macchi S.p.A., Varese, Italy) *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 7 p Mar. 1990
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In the method of ficticious gas for transonic airfoil modification, an attempt was made to introduce a fully elliptic calculation code by the use of compressibility sources. This is done both with the idea of overcoming some of the finite-difference limitations and in order to reduce the computational time. Taking as reference the standard Hess-Smith panel method in two dimensions, compressibility effects are taken into account by means of source panels into the flowfield. The panels form a grid which is limited in extension only where Mach number gradients are expected and much more limited compared to usual computational domains. The system is fast and in general does not present convergence problems from the practical point of use, although large numbers of iterations may have some convergence problems. The final result is always a very strong reduction in wave drag of the airfoil, as it is the aim of the method. Author

N90-20986# Middle East Technical Univ., Ankara (Turkey).
A COMPUTATIONAL DESIGN METHOD FOR SHOCK FREE TRANSONIC CASCADES AND AIRFOILS
T. A. CETINKAYA, I. S. AKMANDOR, and AHMET S. UCER *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 10 p Mar. 1990
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A computational method was formulated for efficient inverse design of blading. The surface pressure distribution is specified and, as a result, the geometric shape of an airfoil or cascade blade is obtained. A steady, two-dimensional Euler code for transonic flow was implemented. The code uses a finite volume technique on a computational grid which is based on assumed streamlines. The grid is being updated during the solution procedure. The blade contour, being a streamline, corresponds to a part of the solution domain boundary where the desired pressure distribution is given. Free parameters are introduced into the prescribed pressure distribution and this satisfies the closure constraints. Examples based on redesign of known shapes are presented. Author

N90-20987# Stuttgart Univ. (Germany, F.R.). Inst. fuer Aero- und Gasdynamik.
INVERSE COMPUTATION OF TRANSONIC INTERNAL FLOWS WITH APPLICATION FOR MULTI-POINT-DESIGN OF SUPERCRITICAL COMPRESSOR BLADES
E. SCHMIDT and F. KLIMETZEK (Daimler-Benz A.G., Stuttgart, Germany, F.R.) *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 13 p Mar. 1990
Sponsored by Deutsche Forschungsgemeinschaft and Forschungsvereinigung Verbrennungskraftmaschinen
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The method solves the inverse problem for supercritical blade-to-blade flow on stream surfaces of revolution with variable radius and variable stream surface thickness in a relative system. Some provisions for the treatment of the ill-posed design problem in local supersonic regions are discussed. A procedure for the design of cascades with improved off-design behavior is described and compared with experimental results. Comparisons with other numerical methods and experimental results are also included. Author

N90-20991*# Sverdrup Technology, Inc., Eglin AFB, FL.
AERODYNAMIC OPTIMIZATION BY SIMULTANEOUSLY UPDATING FLOW VARIABLES AND DESIGN PARAMETERS
M. H. RIZK *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 18 p Mar. 1990
(Contract NAS3-24855; NAS2-12157)
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The application of conventional optimization schemes to aerodynamic design problems leads to inner-outer iterative procedures that are very costly. An alternative approach is presented based on the idea of updating the flow variable iterative solutions and the design parameter iterative solutions simultaneously. Two schemes based on this idea are applied to problems of correcting wind tunnel wall interference and optimizing advanced propeller designs. The first of these schemes is applicable to a limited class of two-design-parameter problems with an equality constraint. It requires the computation of a single flow solution. The second scheme is suitable for application to general aerodynamic problems. It requires the computation of several flow solutions in parallel. In both schemes, the design parameters are updated as the iterative flow solutions evolve. Computations are performed to test the schemes' efficiency, accuracy, and sensitivity to variations in the computational parameters. Author

N90-20992# National Aerospace Lab., Amsterdam (Netherlands).
CONSTRAINED SPANLOAD OPTIMIZATION FOR MINIMUM DRAG OF MULTI-LIFTING-SURFACE CONFIGURATIONS
R. F. VANDEDAM *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 14 p Mar. 1990
Sponsored by Netherlands Agency for Aerospace Programs
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An interactive computer program system was developed that can be used in aircraft drag minimization studies. It comprises algorithms for choosing the spanwise distributions of lift, pitching moment, chord, and thickness-to-chord ratio of lifting elements. The choices are optimal in that they minimize induced plus viscous drag while satisfying constraints of aerodynamic, flight-mechanical and structural nature. The configurations that can be dealt with,

may consist of a number of segments representing, for instance, wings or parts of wings, horizontal tails or canards, winglets or flaprail-fairings. Also the interaction between propellers and lifting elements may be included in the procedure. The induced drag is computed using the Trefftz-plane integral (farfield analysis), while the viscous drag follows from form factor methods. Mathematical formulations of the constrained optimization problems are used, that are based on the calculus of variations. The method was integrated in an infrastructure that allows the capabilities of the method to be efficiently exploited in a multidisciplinary environment. The theoretical models and methods underlying the analysis and optimization capability, comparisons with other theories, information aspects, and some examples of applications, are presented.
Author

N90-20993# National Aerospace Lab., Amsterdam (Netherlands).
NUMERICAL OPTIMIZATION OF TARGET PRESSURE DISTRIBUTIONS FOR SUBSONIC AND TRANSONIC AIRFOIL DESIGN
J. A. VANEGMOND *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 11 p Mar. 1990
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Inverse aerodynamic design, calculating the geometry from prescribed pressure distributions, leaves the designer with the problem to define proper target pressure distributions. Numerical optimization techniques are employed to support the aerodynamic designer in the definition of target pressure distributions for subsonic and transonic airfoil design. A general parametric representation of airfoil pressure distributions is given, taking into account the physical characteristics of the airfoil flow. This parametric representation enables the designer to define optimum target pressure distributions through numerical optimization techniques. Worked out examples show that a large class of airfoils can be described by the proposed procedure, a simple line search method. In general, a large number of iterations is needed to arrive at the final (optimal) solution. However the requirement of a large number of iterations is not a serious drawback of the approach described. Finally, it is concluded that application of numerical optimization techniques is not (yet) to be considered as a routine job but considerable possibilities are offered to improve design results.
Author

N90-20994# Aeronautica Macchi S.p.A., Varese (Italy). Dept. of Advanced Studies.
A TOOL FOR AUTOMATIC DESIGN OF AIRFOILS IN DIFFERENT OPERATING CONDITIONS
L. GHIELMI, R. MARAZZI, and A. BARON (Politecnico di Milano, Italy) *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 12 p Mar. 1990
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An optimization procedure is described which applies to the design of airfoils able to satisfy requirements essentially set for transonic flight. Suitable airfoils are obtained through radical changes of the starting geometry with little time consumption. One of the main features of the design methodology is an extensive use of constraints; it proved to be very efficient both to obtain a good quality of the design and to reduce the time needed. Another feature is the use of effective shape functions, which are not aerofunctions obtained through inverse methods. The results show airfoils designed to satisfy both a maneuver and a dash performance requirement. A comparison of different design approaches is also presented; this is made possible by the short times required for the design, which includes the optimized deflections of the leading edge and trailing edge flaps. Suggestions are given for further developments of a smart system for airfoil design.
Author

N90-20995# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
THE USE OF NUMERICAL OPTIMIZATION FOR HELICOPTER AIRFOIL AND BLADE DESIGN
J. RENEAUX and M. ALLONGUE (Aerospatiale, Marignane, France) *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 12 p Mar. 1990 In FRENCH, ENGLISH summary
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The numerical optimization methods were successfully applied to airfoil design at ONERA, and to helicpter blade design at the Aerospatiale Helicopter Department. The constrained minimization method chosen is the one developed by Vanderplaats. For the design of helicopter airfoils, the minimization algorithms and transonic viscous flow analysis method are linked together. The design of a 12 percent thick airfoil and a 9 percent thick airfoil for helicopter blades were carried out with two design points, one corresponding to the advancing blade conditions and the other to the retreating blade conditions in forward flight. Two-dimensional tests performed in the ONERA S3MA wind tunnel confirmed the theoretical predicted gains. The design of helicopter blades is achieved through the association of the minimization method and a rotor performance analysis method using the blade element theory. The optimization of the spanwise locations of the airfoils of different thickness-to-chord ratios were carried out with one or two design points corresponding to different flight conditions. The method was applied to the rotor design for a helicopter of the 8 to 10 tons gross weight class. The applications discussed show the interest of the numerical optimization techniques for the helicopter rotor design particularly when several flight conditions and many parameters and constraints have to be taken into account.
Author

N90-20996# Dornier-Werke G.m.b.H., Friedrichshafen (Germany, F.R.).
AERODYNAMIC DESIGN BY OPTIMIZATION
K.-W. BOCK *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 12 p Mar. 1990
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The experience gained when coupling different aerodynamic analysis codes and optimization procedures is described. First a simple problem is considered (airfoil of minimum wave drag, analysis by shock expansion theory) in order to compare the usability of a random search procedure to that of a gradient method (COPES by G. N. Vanderplaats). The second one shows a superior performance. Then three aerodynamic programs are coupled with COPES and tested: Euler space-marching program for bodies of revolution at supersonic; transonic airfoil redesign method (fictitious gas concept); and multiple airfoil analysis code for flap position optimization. It can be demonstrated that COPES is a very universal optimization tool which can be easily combined even with complex aerodynamic codes. Its convergence is good even under constraints. This is important because the number of analysis calculations is most important for typical aerodynamic problems of high numerical expense.
Author

N90-20997# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
NUMERICAL OPTIMIZATION OF WINGS IN TRANSONIC FLOW
D. DESTARAC, J. RENEAUX, and D. GISQUET (Aerospatiale, Toulouse, France) *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 12 p Mar. 1990 In FRENCH; ENGLISH summary
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The numerical optimization method for wings in transonic flow presented associates a constrained minimization program, a fast

direct aerodynamic code, and a shape modification technique. Possibilities of optimization with regard to the total aerodynamic coefficients of a wing are shown. A method for estimating inviscid drag is recommended. Two application cases of the optimization method in the quasi inverse mode, by aiming at a given pressure distribution, are described. One is the adaptation of the inner part of a transport aircraft wing, a problem to which optimization is a well suited approach, considering the highly three-dimensional phenomena involved, and the necessity of respecting constraints related to the aircraft design. Another example, the modification of a four-engined jet aircraft in order to reduce perturbations created by the propulsive system, shows that interference problems between the wing and other components of the aircraft can also be approached by numerical optimization. Author

N90-21000# National Transportation Safety Board, Washington, DC.
BRAKE PERFORMANCE OF THE MCDONNELL DOUGLAS DC-10-30/40 DURING HIGH SPEED, HIGH ENERGY REJECTED TAKEOFFS Special Investigation Report, 1988 - 1989
27 Feb. 1990 38 p
(PB90-917004; NTSB/SIR-90/01) Avail: NTIS HC A03/MF A01 CSCL 01/3

On May 21, 1988, a McDonnell Douglas Corporation DC-10-30 overran the runway during a rejected takeoff (RTO) at the Dallas-Fort Worth International Airport, Texas. The airplane was damaged beyond economical repair, and 8 occupants were injured. The brakes had been certified to FAA-approved procedures, yet failed at only 36 percent of the design requirement. As a result of this accident, the Safety Board conducted a special investigation of DC-10-30/40 brakes. The investigation found that the testing requirements and procedures for certifying DC-10-30/40 brakes were inadequate, that only new brakes were used for the certification tests, and that worn brakes do not have the energy capacity or stopping capability of new brakes. The Safety Board also examined the potential decrease of the accelerate-stop safety margin for RTOs provided in the FAA Approved Airplane Flight Manual. The Safety Board believes that the concerns expressed about the adequacy of the certification process for the DC-10-30/40 may apply to the certification of all transport category airplanes. Recommendations were issued to the Federal Aviation Administration and focus on the following safety issues: certification tests and procedures related to the brakes of the DC-10-30/40; brake wear replacement limits; and airplane stopping distance. Author

N90-21001# European Office of Aerospace Research and Development, London (England). Structures/Structural Materials.
HOTOL STRUCTURES AND MATERIALS AT BRITISH AEROSPACE, WARTON, UK
JAMES G. R. HANSEN 11 Oct. 1989 14 p
(EOARD-LR-90-001) Avail: NTIS HC A03/MF A01

HOTOL is British Aerospace's concept for a single-stage-to-orbit, horizontal take-off and landing aerospace plane. Categories of advanced structural materials for HOTOL are summarized and where on the structure these materials would be utilized is shown. Author

N90-21002 Department of the Navy, Washington, DC.
INFLATABLE FUEL TANK BUFFER Patent
JACK R. BATES, inventor (to Navy) 12 Dec. 1989 5 p Filed 6 Jun. 1983
(AD-D014446; US-PATENT-APPL-SN-501667; US-PATENT-CLASS-244-135) Avail: US Patent and Trademark Office CSCL 01/3

An inflatable bladder is placed between the wall of an aircraft inlet duct and the liquid fuel to reduce the potential damage caused by hydrodynamic ram effects from a projectile penetrating the fuel tank. The inflatable bladder is inflated by a regulated gas source prior to combat. The inflatable bladder may be formed as a double layered section of a rubber bladder fuel cell type fuel tank, or an inflatable bladder may be bonded to the inner surface of an integral fuel tank wall. GRA

N90-21003# Starmark Corp., Arlington, VA.
AN EARLY OVERVIEW OF TILTROTOR AIRCRAFT CHARACTERISTICS AND PILOT PROCEDURES IN CIVIL TRANSPORT APPLICATIONS Final Report
DAVID L. GREEN, HAROLD ANDREWS, and MICHAEL SARANIERO Dec. 1989 77 p Prepared in cooperation with Federal Aviation Administration, Washington, DC
(Contract DTFA01-89-P-01074)
(DOT/FAA/DS-89/37) Avail: NTIS HC A05/MF A01

A brief description is provided of tiltrotor aircraft, and some of their projected operating characteristics are identified. Two operations are of particular interest: steep approaches into a confined metropolitan vertiport; and approaches into a vertiport without sufficient clear airspace for a conventional missed approach from a low decision height. Both operations are of interest in order to minimize the airspace needed to conduct such operations. A brief simulation was conducted to support the analysis using a fixed base simulator. The flight simulation involved a quick look at innovative and tiltrotor unique maneuvers to identify and evaluate operations at or near the operational limits. The tiltrotor shows promise of permitting much steeper approach and departure maneuvers than what can be done with either an airplane or a helicopter. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A90-32028
GRID AND MESH PATTERNED ELECTRICALLY CONDUCTIVE COATINGS IN IR SYSTEMS
CLARK I. BRIGHT (Optical and Conductive Coatings, Pacheco, CA) IN: Infrared systems and components III; Proceedings of the Meeting, Los Angeles, CA, Jan. 16, 17, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 212-217. refs
Copyright

The application of patterned electrically conductive (EC) coatings in infrared systems is discussed. The design approach, calculated and experimental performance for two different components are described. One component is a 9.5-inch diameter window of clear ZnS with an EC grid coating to provide deicing/defogging capabilities for a shipboard FLIR system. The heating uniformity and optical performance of the window were evaluated. The second patterned EC coating is an EMI shield on a window of ZnSe with a thin ZnS outer layer for improved mechanical properties with little loss of optical properties. The optical and shielding performance of this coated window for an aircraft thermal IR imaging system is reported. Author

A90-32858
SOME SMART STRUCTURES CONCEPTS
G. P. SENDECKYJ and C. A. PAUL (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: Fiber optic smart structures and skins II; Proceedings of the Meeting, Boston, MA, Sept. 5-8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 2-10. refs
Copyright

The smart structures concept, in which the structure is instrumented with a network of sensors and computers to monitor the flight loads environment and structural integrity, and initiate corrective actions, will eventually replace the current individual aircraft tracking system. Herein, two smart structures concepts are discussed in detail and the required research and development indicated. Author

A90-32860
SMART SKINS - A DEVELOPMENT ROADMAP
JOSEPH M. LOCHOCKI (Arvin/Calspan Advanced Technology Center, Buffalo, NY) IN: Fiber optic smart structures and skins II; Proceedings of the Meeting, Boston, MA, Sept. 5-8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 19-47. refs
Copyright

The Air Force Project Forecast II identified a number of key technology initiatives for development. This paper addresses one such initiative, PT-16, Smart Skins. The concept of the Smart Skin is introduced by briefly highlighting its attributes and potential advantages over standard avionics packaging and maintenance, and then goes on to describe some of the key ingredients necessary for its development. Problem areas are brought out along with some of the required trades that must be made. Finally, a time phased development roadmap is introduced which shows the proposed sequence of technology development programs that can, in combination, lead to first functional Smart Skins implementations in narrow-band form in the late 1990s and in wideband form in the first decade of the twenty-first century. A Smart Skins implementation in integral aircraft skin structure form will take at least until 2010. Author

A90-32863
THE IMPACT OF FIBER OPTICS (PHOTONICS) ON FUTURE AIRCRAFT
STANLEY REICH and CHARLES RITTER (Grumman Corp., Aircraft Systems Div., Bethpage, NY) IN: Fiber optic smart structures and skins II; Proceedings of the Meeting, Boston, MA, Sept. 5-8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 77-89.
Copyright

After presenting a development history of military aircraft avionics, an assessment is made of trends in the direction of fiber-optic, or more generally 'photonic' systems which could undertake 'smart structure' enhancement of airframes' reliability, availability, and survivability through superior fault detection/isolation. A representative next-generation fighter concept is presented in which fiber-optic sensors and integrated optics signal-processing technologies are used to continuously monitor not only propulsion and control systems and structural integrity, but also the external threat environment, and to actively respond to it with EM jamming, etc. O.C.

A90-32873
DEVELOPMENT OF A FIBRE OPTIC DAMAGE DETECTION SYSTEM FOR AN AIRCRAFT LEADING EDGE
M. LE BLANC, S. DUBOIS, K. MCEWEN, D. HOGG, B. PARK (Toronto, University, Downsview, Canada) et al. IN: Fiber optic smart structures and skins II; Proceedings of the Meeting, Boston, MA, Sept. 5-8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 196-204. Research supported by NSERC, Ontario Laser and Lightwave Research Centre, Boeing Canada, et al. refs
Copyright

A prototype fiber-optic damage assessment system for an aircraft wing leading edge is described. This system is based on the fracture of embedded optical fibers. The sensor configuration was determined from tests conducted on small coupons. The design and construction of an instrumented wing leading edge panel are reported, and the tests that will be carried out for its evaluation are discussed. Author

A90-32876
SMART STRUCTURES CONCEPT STUDY
HERB SMITH, JR., AMY GARRETT, and CHARLES R. SAFF (McDonnell Aircraft Co., Saint Louis, MO) IN: Fiber optic smart structures and skins II; Proceedings of the Meeting, Boston, MA, Sept. 5-8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 224-229.
Copyright

The application of the smart structures concept to fighter aircraft is explored. The discussion addresses the issues of survivability of the structure during flight and combat, and the supportability of the aircraft as a weapon system. Data from initial investigations of fiber-optic sensors embedded within composite panels and bonded to aluminum specimens are presented. The sensors detect the occurrence of impact and measure the strain. Author

A90-32906
A FIBER OPTIC HEADSET COMPATIBLE WITH POWER-BY-LIGHT
B. D. SHERMAN (McDonnell Douglas Corp., Long Beach, CA), A. J. MENDEZ, T.-C. YAO, and E. M. GARMIRE (Southern California, University, Los Angeles, CA) IN: Fiber optic smart structures and skins II; Proceedings of the Meeting, Boston, MA, Sept. 5-8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 551-557. refs
Copyright

The feasibility of a power by light headset for use in aircraft communication has been explored. The research has focused on defining a system concept which optimizes the optical efficiency of the uplink and the headset 'power-by-light' elements and minimizes the electrical power consumption of the microphone downlink. Breadboards and tests of the critical power-by-light power supply, earphone driver, and downlink elements have been performed. The data from the experiments are presented and analyzed in order to develop design rules and component requirements for the fiber optic, power-by-light headset design. Author

A90-33889#
ADVANCED INTEGRATED AVIONICS TEST SUPPORT CONCEPTS
RANDALL SHEPARD and BRIAN DONLAN (Science Applications International Corp., Panama City, FL) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 18-26. Research sponsored by USAF. refs
(AIAA PAPER 90-1259) Copyright

Advanced avionics featuring highly integrated functional suites, with rapidly reconfigurable common modules and large quantities of embedded software, have prompted the presently reported efforts toward the definition of avionics testing requirements and their standardization. The levels of such tests encompass the various subsystems, the integrated system, the platform/weapons system, and the complete, man-in-the-loop configuration. An overall concept of standardization is proposed which emphasizes an extendable, modular, and hierarchical infrastructure architecture. With this end in view, USAF has recently conducted a Radar Support Environment Study and an Advanced Avionics Support Environment Study. O.C.

A90-33898#
MICROMINIATURE FLIGHT TEST INSTRUMENTATION
GARY HAVEY and DENNIS FERGUSON (Honeywell Systems and Research Center, Minneapolis, MN) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 113-117.
(AIAA PAPER 90-1274) Copyright

Microminiature devices are under development for the recording and transmission of currently unobtainable flight test data. Illustrative cases of this technology are presented, namely: (1) a subminiature telemetry package predicated on monolithic microwave ICs, which is sufficiently small to fit within fully functional submunitions for testing, and (2) a miniature solid-state recorder, or 'stand-alone measurement device', consisting of a battery-powered, self-activating sensor that can be mounted in remote vehicle locations to furnish instrumentation where conventional wiring is not feasible. O.C.

A90-33913#
F-15E TERRAIN FOLLOWING TEST RESULTS

T. J. SITZ (McDonnell Aircraft Co., Saint Louis, MO) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 271-282.
(AIAA PAPER 90-1299) Copyright

The Low Altitude Navigation and Targeting IR for Night (LANTIRN) furnishes the low-level, day/night terrain-following penetration capability over all terrain types required by the F-15E dual-role fighter. The LANTIRN system encompasses separate navigation and targeting pods; the former employs a forward-looking IR (FLIR) sensor and terrain-following radar (TFR). A 61-flight test, 132-flight hour verification program has been conducted which gave attention to the integration of the FLIR and TFR systems with F-15E avionics, flight controls, and crew station displays. Favorable overall results have been obtained. O.C.

A90-33916#
TESTING OF A HIGHLY INTEGRATED AUTOMATIC FLIGHT SYSTEM - THE 747-400 FLIGHT MANAGEMENT COMPUTER SYSTEM
ROGER K. NICHOLSON and DANIEL W. HREHOV (Boeing Commercial Airplanes, Seattle, WA) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 297-306. refs
(AIAA PAPER 90-1302) Copyright

Flight testing techniques used in the development and certification of the Flight Management Computer System (FMCS) for the Boeing Model 747-400 are outlined. The description covers activities that started well before the aircraft's first flight and continued through Type Certification. A brief description of the 747-400 is presented, along with an overview of the flight test program. A variety of pertinent data collection techniques are elucidated. Testing techniques describing ground testing and instrumentation checkout, laboratory testing and concurrent and dedicated flight testing are reported. Postflight data reduction and analysis are reviewed, emphasizing the need for rapid data turnaround. A discussion of some aspects of FMCS operation revealed during flight testing is followed by a review of recommendations for future FMCS testing. Author

A90-33917#
ONBOARD MAINTENANCE SYSTEM TESTING - THE BOEING 747-400 CENTRAL MAINTENANCE COMPUTER
ROGER K. NICHOLSON and KENNETH W. WHITFIELD (Boeing Commercial Airplanes, Seattle, WA) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 307-316.
(AIAA PAPER 90-1303) Copyright

The 747-400 airliner's designers have adopted an integrated approach to systems maintenance whose most fundamental achievement has been the development of the Central Maintenance Computer (CMC). The CMC automatically monitors 140 separate aircraft LRUs associated with over 70 different aircraft subsystems. Due to the complexity of the integrated systems of the 747-400, testing and certification of the CMC have posed significant challenges; an evolutionary developmental testing approach has accordingly been adopted in order to achieve incremental system improvements, using PCs for convenient and rapid real-time data recording and analysis. O.C.

A90-33930#
AUTOPILOT FLIGHT TEST EXPERIENCE WITH BK 117 HINGELESS ROTOR
M. VON GERSDORFF (MBB GmbH, Munich, Federal Republic of Germany) and TERRY KUNTZ (Honeywell, Inc., Minneapolis, MN) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 449-459.
(AIAA PAPER 90-1267) Copyright

A Digital Automatic Flight Control System (DAFCS) allowing both dual and single pilot IFR operation has been incorporated into the BK 117 helicopter. The DAFCS employs a sophisticated computer architecture which, in order to meet both operational and safety requirements, has required the development of a complete duplex pitch-axis/yaw-axis computation feature whose output controls a single actuator. An account is given of the flight tests performed to optimize all control-law parameters and harmonize monitoring over the entire flight envelope. O.C.

A90-34584
DEVELOPMENT AND OPERATING EXPERIENCE ON A ZINC-SULFIDE WINDOW FOR THE INFRARED INSTRUMENTATION SYSTEM (IRIS)
GERALD W. DRIGGERS (Automated Sciences Group, Inc., Huntsville, AL) and EUGENE D. TIDWELL (U.S. Army Strategic Defense Command, Huntsville, AL) IN: Window and dome technologies and materials; Proceedings of the Meeting, Orlando, FL, Mar. 27-29, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 359-367.
Copyright

The U.S. Army Strategic Defense Command has developed and deployed the IRIS to gather signature data on objects reentering the earth's atmosphere. Airborne multiple calibrated IR imaging cameras make it possible to obtain data in two wavebands simultaneously at high altitudes in close proximity to many targets. A large zinc sulfide window designed to provide good transmission in visible and IR wavebands has been installed in a removable hatch used in conjunction with an aircraft. This window has successfully performed up to its original specifications and is providing valuable operating experience for design of future systems using similar materials. R.E.P.

N90-20080*# Eagle Engineering, Inc., Hampton, VA.
THE NASA DIGITAL VGH PROGRAM: EXPLORATION OF METHODS AND FINAL RESULTS. VOLUME 2: L 1011 DATA 1978-1979: 1619 HOURS
NORMAN L. CRABILL Dec. 1989 175 p
(Contract NASW-4430; DTFA03-890-A-00019)
(NASA-CR-181909-VOL-2; NAS 1.26:181909-VOL-2; DOT/FAA-CT-89/36-2) Avail: NTIS HC A08/MF A01 CSCL 01/4

Data obtained from the digital flight data recorder system of a L 1011 aircraft in 914 flights and 1619 hours of airline revenue operations are presented. Data on conditions with flap deployment and autopilot use are given. In addition, acceleration statistics are presented from 23 hours on nonrevenue flights. Author

N90-20081*# Eagle Engineering, Inc., Hampton, VA.
THE NASA DIGITAL VGH PROGRAM. EXPLORATION OF METHODS AND FINAL RESULTS. VOLUME 1: DEVELOPMENT OF METHODS
NORMAN L. CRABILL Dec. 1989 131 p
(Contract NASW-4430)
(NASA-CR-181909-VOL-1; NAS 1.26:181909-VOL-1; DOT/FAA-CT-89/36-1) Avail: NTIS HC A07/MF A01 CSCL 01/4

Two hundred hours of Lockheed L 1011 digital flight data recorder data taken in 1973 were used to develop methods and procedures for obtaining statistical data useful for updating airliner airworthiness design criteria. Five thousand hours of additional data taken in 1978 to 1982 are reported in volumes 2, 3, 4 and 5. Author

N90-20082*# Eagle Engineering, Inc., Hampton, VA.
THE NASA DIGITAL VGH PROGRAM. EXPLORATION OF METHODS AND FINAL RESULTS. VOLUME 3: B 727 DATA 1978-1980: 1765 HOURS
NORMAN L. CRABILL Dec. 1989 175 p
(Contract NASW-4430)
(NASA-CR-181909-VOL-3; NAS 1.26:181909-VOL-3; DOT/FAA-CT-89/36-3) Avail: NTIS HC A08/MF A01 CSCL 01/4

B 727 digital flight data recorder data taken in 1978 through 1980 were analyzed to provide many statistical data useful for updating airliner airworthiness design criteria. Author

N90-20083*# *Eagle Engineering, Inc., Hampton, VA.*
THE NASA DIGITAL VGH PROGRAM: EXPLORATION OF METHODS AND FINAL RESULTS. VOLUME 4: B 747 DATA 1978-1980, 1689 HOURS
NORMAN L. CRABILL Dec. 1989 174 p
(Contract NASW-4430)
(NASA-CR-181909-VOL-4; NAS 1.26:181909-VOL-4; DOT/FAA-CT-89/36-4) Avail: NTIS HC A08/MF A01 CSCL 01/4

B 747 digital flight data taken in 1978 through 1980 were analyzed to provide many statistical data useful for updating airliner airworthiness design criteria. Author

N90-20084*# Eagle Engineering, Inc., Hampton, VA.
THE NASA DIGITAL VGH PROGRAM: EXPLORATION OF METHODS AND FINAL RESULTS. VOLUME 5: DC 10 DATA 1981-1982, 129 HOURS
NORMAN L. CRABILL Dec. 1989 139 p
(Contract NASW-4430)
(NASA-CR-181909-VOL-5; NAS 1.26:181909-VOL-5; DOT/FAA-CT-89/36-5) Avail: NTIS HC A07/MF A01 CSCL 01/4

DC 10 digital flight data recorder data taken in 1981 through 1982 were analyzed to provide statistical data useful for updating airliner airworthiness design criteria. Author

N90-21004*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STEREOPSIS CUEING EFFECTS ON HOVER-IN-TURBULENCE PERFORMANCE IN A SIMULATED ROTORCRAFT
RUSSELL V. PARRISH and STEVEN P. WILLIAMS (Army Aviation Systems Command, Hampton, VA.) Washington May 1990 62 p
(Contract DA PROJ. 1L1-61102-AH-45)
(NASA-TP-2980; L-16652; NAS 1.60:2980; AVSCOM-TR-90-B-002) Avail: NTIS HC A04/MF A01 CSCL 01/4

The efficacy of stereopsis cueing in pictorial displays was assessed in a real-time piloted simulation experiment of a rotorcraft precision hover-in-turbulence task. Seven pilots endeavored to maintain a hover by visually aligning a set of inner and outer wickets (major elements of a real-world pictorial display, thus attaining the desired hover position, in a full factorial experimental design. The display conditions examined included the presence or absence of a velocity display element (a velocity head-up display) as well as the stereopsis cueing conditions, which included non-stereo (binoptic or monoscopic - no depth cues other than those provided by a perspective, real-world display), stereo 3-D, and hyper stereo (telestereoscopic). Subjective and objective results indicated that the depth cues provided by the stereo displays enhanced the situational awareness of the pilot and enabled improved hover performance to be achieved. The velocity display element also improved the hover performance, with the best hover performance being achieved with the combined use of stereo and the velocity display element. Pilot control input data revealed that less control action was required to attain the improved hover performance with the stereo displays. Author

N90-21005*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SIMULATOR COMPARISON OF THUMBALL, THUMB SWITCH, AND TOUCH SCREEN INPUT CONCEPTS FOR INTERACTION WITH A LARGE SCREEN COCKPIT DISPLAY FORMAT
DENISE R. JONES and RUSSELL V. PARRISH Apr. 1990 31 p
(NASA-TM-102587; NAS 1.15:102587) Avail: NTIS HC A03/MF A01 CSCL 01/4

A piloted simulation study was conducted comparing three different input methods for interfacing to a large screen, multiwindow, whole flight deck display for management of transport aircraft systems. The thumball concept utilized a miniature trackball embedded in a conventional side arm controller. The multifunction control throttle and stick (MCTAS) concept employed a thumb switch located in the throttle handle. The touch screen concept provided data entry through a capacitive touch screen installed on the display surface. The objective and subjective results obtained indicate that, with present implementations, the thumball concept was the most appropriate for interfacing with aircraft systems/subsystems presented on a large screen display. Not unexpectedly, the completion time differences between the three concepts varied with the task being performed, although the thumball implementation consistently outperformed the other two concepts. However, pilot suggestions for improved implementations of the MCTAS and touch screen concepts could reduce some of these differences. Author

N90-21006*# Aerometrics, Inc., Sunnyvale, CA.
ADVANCED INSTRUMENTATION FOR AIRCRAFT ICING RESEARCH Final Report
W. BACHALO, J. SMITH, and R. RUDOFF Apr. 1990 103 p
(Contract NAS3-25317)
(NASA-CR-185225; NAS 1.26:185225) Avail: NTIS HC A06/MF A01 CSCL 01/4

A compact and rugged probe based on the phase Doppler method was evaluated as a means for characterizing icing clouds using airborne platforms and for advancing aircraft icing research in large scale wind tunnels. The Phase Doppler Particle Analyzer (PDPA) upon which the new probe was based is now widely recognized as an accurate method for the complete characterization of sprays. The prototype fiber optic-based probe was evaluated in simulated aircraft icing clouds and found to have the qualities essential to providing information that will advance aircraft icing research. Measurement comparisons of the size and velocity distributions made with the standard PDPA and the fiber optic probe were in excellent agreement as were the measurements of number density and liquid water content. Preliminary testing in the NASA Lewis Icing Research Tunnel (IRT) produced reasonable results but revealed some problems with vibration and signal quality at high speeds. The cause of these problems were identified and design changes were proposed to eliminate the shortcomings of the probe. Author

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A90-32258#
CYCLE ANALYSIS FOR HELICOPTER GAS TURBINE ENGINES
A. D. BEWLEY (Royal Aerospace Establishment Farnborough, England) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 112, April 1990, p. 199-205. refs
(ASME PAPER 89-GT-328) Copyright

An examination is made of the prospects for performance improvement in both near-term and next-generation helicopter gas turbine engine cycles, in view of emerging technologies in the fields of materials, aerodynamics, and heat-transfer/cooling. Low-SFC requirements entail high turbine-inlet temperatures, high pressure ratios and high component efficiencies whose achievement becomes more difficult with diminishing engine size; one possible course to the resolution of this problem, namely the incorporation of regenerative exhaust-stream heat recovery, is presently highlighted. O.C.

A90-32259#
PROPULSION SYSTEMS FOR SUPERSONIC V/STOL AIRCRAFT
W. J. LEWIS (Rolls-Royce, PLC, Bristol, England) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 112, April 1990, p. 206-211.
(ASME PAPER 89-GT-309) Copyright

A comprehensive evaluation is made of the configurational features and comparative advantages of the numerous powerplant/airframe integrations under consideration for supersonic flight-capable V/STOL military aircraft. The concepts considered encompass thrust-vectoring with plenum-chamber burning, mixed-flow vectored thrust, tandem-fan stages with separate thrust vectoring nozzles, remote augmented (and remote unaugmented) lift, augmenting-ejector lift, nacelle-tilting, and lift-plus-lift/cruise engines. The operational problems to be faced by evaluation include the achievement of low specific thrust, weight minimization, and exhaust gas reingestion due to 'fountain' recirculation effects. O.C.

A90-32261#
A METHOD OF SIZING MULTI-CYCLE ENGINES FOR HYPERSONIC AIRCRAFT
J. J. KOLDEN (Boeing Co., Seattle, WA) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 112, April 1990, p. 217-222.
(ASME PAPER 89-GT-281) Copyright

A method of sizing multicycle engines for integration with hypersonic vehicles has been developed. The new procedure independently sizes the inlet, each engine cycle, and the nozzle during the vehicle sizing loop to optimize propulsion/aircraft integration. Using uninstalled engine performance for each cycle of a multicycle engine along with inlet and nozzle performance and an estimate of aircraft drag, an iterative procedure is utilized to size each component simultaneously. A propulsion system is defined that meets the aircraft thrust requirements at all mission points. The inlet is sized to provide airflow such that the maximum Mach cruise and/or combat thrust conditions are met. Each cycle is sized independently to meet all thrust requirements while minimizing either inlet drag or engine size. Nozzle sizing must trade off thrust, drag, and nozzle weight. This methodology has been incorporated into a computer code entitled Multi-Cycle Engine Sizing Program, MCESP. Author

A90-32262#
EVALUATION OF CONTROL TECHNIQUES FOR AIRCRAFT PROPULSION SYSTEMS
L. E. ROSENBLAD (Douglas Aircraft Co., Long Beach, CA) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 112, April 1990, p. 229-232.
Copyright

Novel aircraft propulsion system control methods which can furnish the numerous benefits of multivariable optimization and guaranteed robustness as aircraft systems become more highly integrated and complex are presently evaluated and verified via computer simulation. The real-time, dynamic system-simulation facility that has been developed possesses multivariable compensator generation and hardware-in-the-loop closure; it is intended to serve as a way-station to full test-flight capability which retains design and test flexibility. Sensor-synthesis and noise-injection features are incorporated which ensure simulation applicability to real-world implementation tasks. O.C.

A90-32269#
PROBABILISTIC METHOD TO COMPUTE THE OPTIMAL SLIP LOAD FOR A MISTUNED BLADED DISK ASSEMBLY WITH FRICTION DAMPERS
S. CHEN and A. SINHA (Pennsylvania State University, University Park) ASME, Transactions, Journal of Vibration and Acoustics (ISSN 0739-3717), vol. 112, April 1990, p. 214-221. refs
(Contract NSF MSM-85-04579)
Copyright

In this paper, an analytical technique has been developed to compute the statistics of forced response of a mistuned bladed disk assembly with friction dampers (blade-to-blade or blade-to-ground). The method is based on the statistical linearization approach and predicts the probability distribution function of a blade's amplitude. The validity of this technique has been corroborated by comparison with the results from numerical simulations. Using this technique, the optimal value of the slip load at the friction joint has been computed to minimize the probability that a blade's amplitude will exceed a critical value. Author

A90-32421#
MULTIVARIABLE CONTROL OF JET ENGINES
MASAHIRO KUROSAKI and SHIGEKI MURAYAMA Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 29, Nov. 1989, p. 405-410. In Japanese, with abstract in English. refs

In order to meet higher performance requirements, aeroengines have been making increasing use of variable geometry which necessitates well coordinated multiinput controls (Multivariable Control). Any sophisticated control laws and logic can be easily implemented into Digital Electron Controls which have been recently introduced to the field of aeroengines. LQI (Linear Quadratic Integral control), output feedback, and PID controllers have been designed to investigate the Multivariable Control of Reheat Turbofan Engines. LQI controllers have shown the best performance by a comparison of the linear quadratic performance indices. Engines are at intermediate power at sea level static conditions, and the control modes, fan speed and turbine exit temperature control, and fan speed and engine exit pressure control are taken into account. Here the robust stability of LQI controllers of two control modes are studied by drawing sigma-plots, and an example of step response is also shown. Author

A90-32808
A MODEL GAS TURBINE COMBUSTOR WITH WALL JETS AND OPTICAL ACCESS FOR TURBULENT MIXING, FUEL EFFECTS, AND SPRAY STUDIES
C. D. CAMERON, J. BROUWER, and G. S. SAMUELSEN (California, University, Irvine) IN: Symposium (International) on Combustion, 22nd, Seattle, WA, Aug. 14-19, 1988, Proceedings. Pittsburgh, PA, Combustion Institute, 1989, p. 465-473; Discussion, p. 473, 474. refs
(Contract F08635-86-C-0309)
Copyright

Turbulent transport, fuel effects, and spray dynamics in gas turbine combustor type flows are studied by using a model laboratory reactor with optical access and wall jets. Laser anemometry and a thermocouple probe are used to characterize aerodynamic and thermal fields respectively, while Doppler interferometry is used to resolve droplet size and droplet velocity fields. It is shown that the structure of the dome region recirculation is relatively insensitive to a change from a step to a 45-degree divergent dome expansion, while the primary air provides closure to the dome recirculation and enhances the turbulent mixture. V.T.

A90-32951#
INVESTIGATION OF COWL VENT SLOTS FOR SUPERCRITICAL STABILITY ENHANCEMENT IN DUAL-MODE RAMJET INLETS
M. E. WHITE, J. R. STEVENS, D. M. VAN WIE, L. A. MATTES, and J. L. KEIRSEY (Johns Hopkins University, Laurel, MD) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, May-June 1990, p. 225, 226. Abridged. Previously cited in issue 18, p. 3006, Accession no. A88-45617.
Copyright

A90-32960*# General Motors Corp., Indianapolis, IN.
DESIGN OF AN AIR-COOLED METALLIC HIGH-TEMPERATURE RADIAL TURBINE
PHILIP H. SNYDER (General Motors Corp., Indianapolis, IN) and RICHARD J. ROELKE (NASA, Lewis Research Center, Cleveland,

OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, May-June 1990, p. 283-288. Previously cited in issue 18, p. 3006, Accession no. A88-45011. refs
(Contract NAS3-24230; DDAJ02-77-C-0031)
Copyright

A90-32961#
ELIMINATING THE TF30 P-111 + ENGINE ROTOR-INSTABILITY PROBLEM
J. T. AKIN, V. S. FEHR (United Technologies Corp., Pratt and Whitney Group, West Palm Beach, FL), and D. L. EVANS (USAF, Air Logistics Center, Oklahoma City, OK) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, May-June 1990, p. 289-296. Previously cited in issue 18, p. 3006, Accession no. A88-44843. refs
Copyright

A90-32962#
EXPERIMENTAL STUDIES OF COMBUSTOR DILUTION ZONE AERODYNAMICS. I - MEAN FLOWFIELDS
S. J. STEVENS and J. F. CARROTTE (Loughborough University of Technology, England) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, May-June 1990, p. 297-304. Sponsorship: Ministry of Defence. Previously cited in issue 20, p. 3155, Accession no. A87-45232. refs
(Contract MOD-ER/2170/090/XR)
Copyright

A90-32964*# Analatom, Inc., San Jose, CA.
NUMERICAL SIMULATIONS OF AN OBLIQUE DETONATION WAVE ENGINE
JEAN-LUC CAMBIER (Analatom, Inc., San Jose, CA), HENRY ADELMAN, and GENE P. MENEES (NASA, Ames Research Center, Moffett Field, CA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, May-June 1990, p. 315-323. Previously cited in issue 07, p. 950, Accession no. A88-22043. refs
Copyright

A90-32966#
TURBINE COMBUSTOR PRELIMINARY DESIGN APPROACH
A. M. MELLOR (Drexel University, Philadelphia, PA) and K. J. FRITSKY Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, May-June 1990, p. 334-343. Research supported by the General Motors Corp. refs
(Contract NSF ENG-87-12997)
Copyright

Semiempirical correlation calibrated with data from a wide variety of existing gas turbine combustors are rearranged and organized into a burner design methodology, yielding position and size of primary and secondary air penetration holes and swirler angle, as well as required atomization from both pilot and main fuel injectors at engine start and low power operating conditions. Output parameters are based on quantitative specifications of maximum NO(x) and CO emissions indices, maximum blowout fuel/air ratio at start and idle power, minimum combustion efficiency, and coldest fuel temperature at start (ground or at altitude). Insofar as possible, the methodology is verified with measurements for the three configurations of a can combustor developed for vehicular applications. Author

A90-33347
ADVANCED POWER SYSTEM FOR 21ST CENTURY FIGHTER AIRCRAFT
FRED KLAASS (Allied-Signal Aerospace Co., Garrett Auxiliary Power Div., Torrance, CA) Aerospace Engineering (ISSN 0736-2536), vol. 10, May 1990, p. 17-20.
Copyright

To increase crew and aircraft survivability for 21st century fighters, engineers have studied a power system which would be able to supply increased power at high altitudes, at the touch of a button. In the event of an aircraft power outage, this emergency power would help the pilot re-establish aircraft control and restart the propulsion engine(s). The heart of the system is a gas turbine, an integrated power unit (IPU) designed to restart the engines and supply 149 kW in two seconds using a stored oxidizer. USAF goals for higher power density and reliability, as well as improved fuel consumption, have driven the design of the IPU power system. System goals and some power system concepts are provided. R.E.P.

A90-33349
NEW POWER SYSTEM ARCHITECTURE FOR THE 747-400
JIM THOM and JOHN FLICK (Sunstrand Corp., Rockford, IL) Aerospace Engineering (ISSN 0736-2536), vol. 10, May 1990, p. 31-35.
Copyright

The 747-400 contains features which provide automatic noninterrupt power transfer, load management, and fully selective protection. The electric power system (EPS) has improved the quality and maintainability of power, while decreasing crew workload. Details of the various component parts of the system are provided along with circuitry diagrams and layouts of crew operational and maintenance panels. The 747-400 EPS incorporates features unique to modern commercial aircraft. With its microprocessor-based controls it provides an increase in continuity of power to the loads, redundancy in control, protection, and communication, and an extensive built-in test scheme. R.E.P.

A90-33559#
SURFACE ROUGHNESS MEASUREMENTS ON GAS TURBINE BLADES
R. P. TAYLOR (Mississippi State University, Mississippi State) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 112, April 1990, p. 175-180. Research supported by USAF. refs
(ASME PAPER 89-GT-285) Copyright

Results are presented from profilometer measurements of the surface roughness on in-service turbine engine blades from F-100 and TF-39 aeroengines. On each blade, one roughness profile is taken in the region of the leading edge, the midchord and the trailing edge on both the pressure and suction sides for a total of six profiles. Thirty first-stage turbine blades are measured from each engine. Statistical computations are performed on these profiles and the root mean square height, skewness and kurtosis of the roughness height distribution are presented along with the correlation length of the autocorrelation function. The purpose of this work is to provide insight into the nature of surface roughness characteristics of in-service turbine blades which can be used in the development of scaled laboratory experiments of boundary layer flow and heat transfer on turbine engine blades. Author

A90-33591
INFLUENCE OF FUEL DROP SIZE AND COMBUSTOR OPERATING CONDITIONS ON POLLUTANT EMISSIONS
K. K. RINK and A. H. LEFEBVRE (Purdue University, West Lafayette, IN) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 6, no. 2, 1989, p. 113-121. Research supported by DOE. refs
Copyright

Tests are conducted in a tubular, gas-turbine type combustor, containing a 15 cm diameter combustion liner. The fuel injector comprises a circular array of 36 'microscopic' plain-jet airblast atomizers which is incorporated into a perforated plate flameholder. Standard instrumentation and sampling techniques are used to measure pollutant emissions over wide ranges of mean fuel drop size. The fuel employed is diesel oil (DF2). The results obtained demonstrate the effects of variations in fuel drop size and combustor operating conditions on the emissions of carbon monoxide, unburned hydrocarbons, oxides of nitrogen, and particulates, over a range of pressures from 0.76 to 1.27 MPa (7.5 to 12.5 atoms) and for inlet air temperatures from 473 to 773 K. Author

A90-33594
DYNAMICS OF MULTI-SPOOL GAS TURBINES USING THE MATRIX TRANSFER METHOD - APPLICATIONS
Y. KAZAO (Toshiba Corp., Heavy Apparatus Engineering Laboratory, Yokohama, Japan) and E. J. GUNTER (Virginia, University, Charlottesville) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 6, no. 2, 1989, p. 143-152.
Copyright

Application of the modified matrix transfer method in which multispan rotors with multiple branches can be computed accurately and rapidly on a microcomputer is presented. The procedure is used for the dynamic analysis of turborotors with flexible supports and flexible offset impellers and fans, turbine-generators on flexible foundations, and multispool gas turbines with flexible casings. Several rotor dynamic case studies, using simple models of a rotor coupled with a casing or foundation, are also presented. A dynamic analysis of a gas turbine with dual-span rectors (a low pressure rotor and a high pressure rotor) with flexible disks and a flexible casing is discussed. It is shown that the gas turbine system critical speeds cannot be computed using single span theory and that the interaction of flexible casing or foundation with the rotor may cause multiple or bifurcated critical speeds to occur within the operating speed range. Author

A90-33595
DYNAMICS OF MULTI-SPOOL GAS TURBINES USING THE MATRIX TRANSFER METHOD - THEORY
Y. KAZAO (Toshiba Corp., Heavy Apparatus Engineering Laboratory, Yokohama, Japan) and E. J. GUNTER (Virginia, University, Charlottesville) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 6, no. 2, 1989, p. 153-161. refs
Copyright

A theoretical procedure for the dynamic analysis of multi-spool turborotors with flexible supports and flexible branches using a modified transfer method in which multi-span rotors with multiple branches may be computed accurately and rapidly on a small engineering workstation is presented. A scaling procedure is introduced into the transfer matrices by appropriate transformations of slope, moment, and shear coefficients. The numerical difficulties caused by branches are described using a simple model and methodology to eliminate this problem is developed. A computer algorithm used to calculate undamped critical speeds of multi-span rotors with multiple branches is studied. R.E.P.

A90-33894#
F-15E/GE-129 INCREASED PERFORMANCE ENGINE INITIAL DEVELOPMENT FLIGHT TEST PROGRAM
J. W. DELISI (McDonnell Aircraft Co., Saint Louis, MO) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 66-77.
(AIAA PAPER 90-1266) Copyright

An evaluation is made of the methods and results of the F110-GE-129 Increased Performance Engine/F-15E initial development flight test program, which involved 21 flights and encompassed air-stars of the engines, control mode transfers, throttle transients, climbs, maximum power accelerations, and an alternative fuel (JP-8) evaluation. A preliminary analysis of test data has indicated that the engines provided the expected 25-percent increase in thrust over current PW-220 engines. Supersonic cruise without afterburner was demonstrated at both 20,000 and 40,000 ft. JP-8 fueled operations were generally similar to those with conventional JP-4. O.C.

N90-20085*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AEROSPACE INDUCTION MOTOR ACTUATORS DRIVEN FROM A 20-KHZ POWER LINK
IRVING G. HANSEN Jan. 1990 5 p Presented at the 4th International Conference on Power Electronics and Variable Speed Drives, London, England, 17-19 Jul. 1990; sponsored by Institution of Electrical Engineers
(NASA-TM-102482; E-5272; NAS 1.15:102482) Avail: NTIS HC A01/MF A01 CSCL 21/5

Aerospace electromechanical actuators utilizing induction motors are under development in sizes up to 40 kW. While these actuators have immediate application to the Advanced Launch System (ALS) program, several potential applications are currently under study including the Advanced Aircraft Program. Several recent advances developed for the Space Station Freedom have allowed induction motors to be selected as a first choice for such applications. Among these technologies are bi-directional electronics and high frequency power distribution techniques. Each of these technologies are discussed with emphasis on their impact upon induction motor operation. Author

N90-20086*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
THE IMPLEMENTATION AND OPERATION OF A VARIABLE-RESPONSE ELECTRONIC THROTTLE CONTROL SYSTEM FOR A TF-104G AIRCRAFT
BRADFORD NEAL and UPAL SENGUPTA Dec. 1989 18 p
(NASA-TM-101696; H-1542; NAS 1.15:101696) Avail: NTIS HC A03/MF A01 CSCL 21/5

During some flight programs, researchers have encountered problems in the throttle response characteristics of high-performance aircraft. To study and to help solve these problems, the National Aeronautics and Space Administration Ames Research Center's Dryden Flight Research Facility (Ames-Dryden) conducted a study using a TF-104G airplane modified with a variable-response electronic throttle control system. Ames-Dryden investigated the effects of different variables on engine response and handling qualities. The system provided transport delay, lead and lag filters, second-order lags, command rate and position limits, and variable gain between the pilot's throttle command and the engine fuel controller. These variables could be tested individually or in combination. Ten research flights were flown to gather data on engine response and to obtain pilot ratings of the various system configurations. The results should provide design criteria for engine-response characteristics. The variable-response throttle components and how they were installed in the TF-104G aircraft are described. How the variable-response throttle was used in flight and some of the results of using this system are discussed. Author

N90-20087*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
STATIC AEROELASTIC ANALYSIS OF A THREE-DIMENSIONAL GENERIC WING
JOHN A. GREEN, IN LEE, and HIROKAZU MIURA Feb. 1990 29 p
(NASA-TM-102231; A-89239; NAS 1.15:102231) Avail: NTIS HC A03/MF A01 CSCL 21/5

A continuation of research on the static aeroelastic analysis of a generic wing configuration is presented. Results of the study of the asymmetric oblique wing model developed by Rockwell International, in conjunction with the NASA Oblique Wing Research Aircraft Program, are reported. The capability to perform static aeroelastic analyses of an oblique wing at arbitrary skew positions is demonstrated by applying the MSC/NASTRAN static analysis scheme modified by the aerodynamic influence coefficient matrix created by the NASA Ames aerodynamic panel codes. The oblique wing is studied at two skew angles, and in particular, the capability to calculate 3-D thickness effects on the aerodynamic properties of the wing is investigated. The ability to model asymmetric wings in both subsonic and supersonic Mach numbers is shown. The aerodynamic influence coefficient matrix computed by the external programs is inserted in MSC/NASTRAN static aeroelasticity analysis run stream to compute the aeroelastic deformation and internal forces. Various aerodynamic coefficients of the oblique wing were computed for two Mach numbers, 0.7 and 1.4, and the angle of attach -5 through 15 deg. Author

N90-20088*# Allied-Signal Aerospace Co., Torrance, CA. AiResearch Los Angeles Div.

DEVELOPMENT AND FABRICATION OF STRUCTURAL COMPONENTS FOR A SCRAMJET ENGINE Final Report, Mar. 1980 - May 1989

O. A. BUCHMANN Mar. 1990 234 p

(Contract NAS1-16097)

(NASA-CR-181945; REPT-89-62543; NAS 1.26:181945) Avail: NTIS HC A11/MF A02 CSCL 21/5

A program broadly directed toward design and development of long-life (100 hours and 1,000 cycles with a goal of 1,000 hours and 10,000 cycles) hydrogen-cooled structures for application to scramjets is presented. Previous phases of the program resulted in an overall engine design and analytical and experimental characterization of selected candidate materials and concepts. The latter efforts indicated that the basic life goals for the program can be reached with available means. The main objective of this effort was an integrated, experimental evaluation of the results of the previous program phases. The fuel injection strut was selected for this purpose, including fabrication development and fabrication of a full-scale strut. Testing of the completed strut was to be performed in a NASA-Langley wind tunnel. In addition, conceptual designs were formulated for a heat transfer test unit and a flat panel structural test unit. Tooling and fabrication procedures required to fabricate the strut were developed, and fabrication and delivery to NASA of all strut components, including major subassemblies, were completed. Author

N90-20089# Oxford Univ. (England). Dept. of Engineering Science.

HEAT TRANSFER NEAR THE ENTRANCE TO A FILM COOLING HOLE IN A GAS TURBINE BLADE M.S. Thesis

AARON R. BYERLEY 1989 240 p Sponsored by AFIT

(AD-A217396; AFIT/CI/CIA-89-107) Avail: NTIS HC A11/MF A02 CSCL 20/13

Film cooling is a method used to prevent jet engine turbine blade failure due to overheating. It consists of bleeding relatively cool air from the engine's compressor stage and discharging it through small holes in the turbine blade surface. This air provides a protective, insulating film which keeps the blade surface temperature well below the destructively high temperature levels of the combustor gases. This thesis presents for the first time, detailed pictures of the convective heat transfer distribution on the wall of an internal turbine blade passage near the entrance to a film cooling hole. The physical situation was modelled at 100X geometric scale as flow extraction into a single circular hole from a two-dimensional, fully developed, turbulent channel flow. High resolution heat transfer measurements were made using a transient technique with liquid crystals as surface temperature indicators. During the experiments, the two-dimensional channel Reynolds number was held constant while the flow extraction rate was varied for each of four hole inclination angles. The main region of heat transfer enhancement was found to be downstream with local heat transfer levels up to 6.5 times the levels associated with turbulent channel flow. Additional experimental, analytical, and computational flow field studies showed that the enhancement was caused mainly by the removal of the upstream boundary layer and the formation of a new laminar boundary layer at the down-stream hole edge. GRA

N90-20090*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

COMPARISON OF 3-D VISCOUS FLOW COMPUTATIONS OF MACH 5 INLET WITH EXPERIMENTAL DATA

D. R. REDDY (Sverdrup Technology, Inc., Cleveland, OH.), T. J. BENSON, and L. J. WEIR Jan. 1990 15 p Presented at the 28th Aerospace Sciences Meeting, Reno, NV, 8-11 Jan. 1990; sponsored by AIAA Previously announced in IAA as A90-26970

(NASA-TM-102518; E-5322; NAS 1.15:102518) Avail: NTIS HC A03/MF A01 CSCL 21/5

A time marching 3-D full Navier-Stokes code, called PARC3D, is validated for an experimental Mach 5 inlet configuration using the data obtained in the 10 x 10 ft supersonic wind tunnel at the NASA Lewis Research Center. For the first time, a solution is obtained for this configuration with the actual geometry, the tunnel conditions, and all the bleed zones modeled in the computation. Pitot pressure profiles and static pressures at various locations in the inlet are compared with the corresponding experimental data. The effect of bleed zones, located in different places on the inlet walls, in eliminating the low energy vortical flow generated from the 3-D shock-boundary layer interaction is simulated very well even though some approximations are used in applying the bleed boundary conditions and in the turbulence model. A further detailed study of the effect of individual bleed ports is needed to understand fully the actual mechanism of efficiently eliminating the vortical flow from the inlet. A better turbulence model would help to improve the accuracy even further in predicting the corner flow boundary layer profiles. Author

N90-20091# General Motors Corp., Indianapolis, IN. Gas Turbine Div.

IN-LINE WEAR MONITOR Final Report, Jul. 1988 - Apr. 1989

KEITH A. PIEPER and IVOR J. TAYLOR (Princeton Gamma Tech, Inc., NJ.) Nov. 1989 51 p

(Contract F33615-85-C-2537)

(AD-A217799; ALLISON-EDR-14074; WRDC-TR-89-2118) Avail: NTIS HC A04/MF A01 CSCL 21/5

This report describes construction and test results of an in-line monitor for critical ferrous and nonferrous metal debris in turbine engine lubrication systems. The in-line wear monitor (ILWM) uses the x ray fluorescence principle for detecting metal debris on a continuous basis while the engine is running. The sensor portion of the system is engine mounted and contains a radioactive x ray source, a flow cell to direct the oil across an x ray permeable window, a proportional counter x ray detector and its associated preamplifier and amplifier electronics. The data acquisition electronics is mounted on the airframe and contains a microprocessor based system for inputting pulses from the sensor, classifying and counting them according to energy bands, and analyzing the data and outputting metal concentration values to the engine monitoring system. The sensor portion of the system is designed to fit on a TF41 turbine engine in place of a tube between the oil tank and the oil pump. A TF41 engine monitoring system has been modified to accept the new signals from the ILWM on spare inputs so that none of the existing functions were disturbed. The ILWM has been flow tested at various flow rates, concentration levels, oil temperatures, and aerations. The wear monitor detected iron, copper, and both iron and copper together. GRA

N90-20985# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).

SUBSONIC AND TRANSONIC BLADE DESIGN BY MEANS OF ANALYSIS CODES

R. A. VANDEBRAEMBUSSCHE, O. LEONARD, and L. NEKMOUCHE *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 11 p Mar. 1990 Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

An iterative procedure for cascade blade design, using a direct flow solver and a blade geometry modification algorithm is presented. The procedure starts with the analysis of a given cascade geometry using an existing flow solver. The difference between the calculated velocity distribution and the required one is used as an input for the modification algorithm. This procedure results in the definition of a new blade shape for which the calculated velocity distribution is closer to the desired one. Examples for both subsonic and transonic flow are presented and show a rapid convergence to the geometry required for the desired velocity distribution. The main advantage of the proposed method is that existing analysis codes can be used, for the design and for the off-design analysis. Some restrictions which have to be imposed on the required velocity distribution are also discussed. Author

N90-20988# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction de l'Aerodynamique.
AN INVERSE METHOD FOR THE DESIGN OF TURBOMACHINE BLADES [UNE METHODE INVERSE POUR LA DETERMINATION D'AUBES DE TURBOMACHINES]
OLIVIER-PIERRE JACQUOTTE *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 16 p Mar. 1990 In FRENCH Sponsored by SNECMA
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An inverse method for the determination of turbomachinery cascade profiles, which can be applied to transonic flow, is described. The method is related to quasi-three-dimensional flow around the blade cascade and is based on the solution of the inverse form of the potential scalar equation associated with the absolute speed in reference to the relative bounds of the blade. The correct mathematical definition of the inverse formula for compressible cascade is examined. The desired profile is obtained after a eries of iterations resulting in parameter adjustments permitted by the convergence. The finite element method is used as the solution technique. The most immediate concern is the preliminary validation of the method and the possibility of restoration of a known profile starting from a gross initialization is shown. Finally, some test cases are shown. Transl. by E.J.R.

N90-20989# Instituto Superior Tecnico, Lisbon (Portugal). Dept. of Mechanical Engineering.
APPLICATION OF AN INVERSE METHOD TO THE DESIGN OF A RADIAL INFLOW TURBINE
JOAO EDUARDO BORGES *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 16 p Mar. 1990 Sponsored in part by Holset Engineering Co., England; Churchill Coll., Cambridge, England; and Junta Nacional de Investigacao Cientifica e Tecnologica, Portugal
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A truly three-dimensional inverse method is described and applied to the design of the rotor of a radial inflow turbine with a specific speed equal to 0.6. The described indirect method uses a mean swirl (i.e. radius times mean tangential velocity) specification and applies to inviscid and incompressible fluid. In addition, it is assumed that the inlet flow is uniform and that the blades are infinitely thin. The action of the blades is modelled by surface vorticity, using the Clebsch formulation for the calculation of the velocity field. The blade shape is evaluated by requiring it to be aligned with the local velocity vectors throughout its entire length. Since the vorticity depends on the blade shape, the problem must be solved iteratively. As the mean swirl specification is not a familiar input design, its physical significance is discussed and some advice is given on the best way of choosing it. Finally, the results of some experimental tests are briefly discussed. In these tests the performance of a rotor designed using the present indirect method was compared with that achieved by an impeller designed using conventional techniques. It is shown that the rotor designed using the inverse method is more efficient than the conventional impeller. Author

N90-20990# Politecnico di Torino (Italy).
NUMERICAL METHOD FOR DESIGNING 3D TURBOMACHINERY BLADE ROWS
L. ZANNETTI, F. LAROCCA (Fiat Aviazione S.p.A., Turin, Italy), and R. MARSILIO *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 9 p Mar. 1990
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The aim is to present a newly improved method to solve inverse problems for inviscid, compressible, rotational flows in 3-D ducts or 3-D rows of blades. A finite-difference time-dependent computation is performed in a channel whose walls are deformable and that adjust themselves to the design data. In the present 3-D formulation the ideas outlined are followed, a mathematical model based on the contravariant components of the flow velocity and a second-order accurated finite-difference scheme are used. A new procedure is used at the boundaries, which is simpler and more rigorous than the previous one. Author

N90-21007 Cincinnati Univ., OH.
LDV MEASUREMENTS AND THE FLOW ANALYSIS IN THE VORTEX REGION OF A RADIAL INFLOW TURBINE Ph.D. Thesis
A. N. LAKSHMINARASIMHA 1989 192 p
Avail: Univ. Microfilms Order No. DA9003252

Detailed measurements were performed in the vortex (vaneless) region of a radial inflow turbine using a three component LDV. First, an error and uncertainty analysis based on a large sample size measurements taken at the inlet and the exit of the vortex region are presented. The flow in the vortex region is then described by contour plots of velocity, flow angle, and whirl velocity contours in the vortex region. In addition pitch averaged mean and turbulence quantities in the vaneless region are also presented. These results indicate that the flow in the vortex region is characterized by a rapid mixing region. Unlike in axial machines, the wake region of the nozzle guide vanes were found to diffuse faster. The non-uniformities in the flow in the circumferential direction were attributed to both the scroll and the nozzle performance. In order to evaluate the degree of non-uniformity in the vortex region, the mass averaged velocity for the sector at different radii from the entrance to the exit was calculated. The percentage difference between the measured actual velocity at a point and the mass averaged velocity at that radii was used to calculate the degree of non-uniformity in the vortex region. The degree of non-uniformity was higher near the plexglass (endwall region) than in a plane near the midchannel. The degree of non-uniformity decreased repidly in the downstream direction. In addition detailed pressure measurements were carried out in the vortex region. Using the measured surface static pressure and velocity total pressure loss was estimated. Total pressure loss was found to be high at the entrance to the vortex zone and near guide vane wake region.
Dissert. Abstr.

N90-21008# Federal Aviation Administration, Atlantic City, NJ.
STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN US COMMERCIAL AVIATION DURING 1986 Final Report
R. A. DELUCIA, J. T. SALVINO (Naval Air Propulsion Test Center, Trenton, NJ.), and B. C. FENTON Jan. 1990 27 p
(DOT/FAA/CT-89/30; NAPC-PE-188) Avail: NTIS HC A03/MF A01

Statistical information relating to gas turbine engine rotor failures which occurred during 1986 in U.S. commercial aviation service use is presented. Two hundred forty-nine failures occurred in 1986. Rotor fragments were generated in 140 of the failures, and of these 16 were uncontained. The predominant failure involved blade fragments, 93 percent of which were contained. Two disk failures occurred and all were uncontained. Sixty-five percent of the 249 failures occurred during the takeoff and climb stages of flight.
Author

N90-21009# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Propulsion and Energetics Panel.
SECONDARY FLOWS IN TURBOMACHINES
Feb. 1990 342 p In ENGLISH and FRENCH Meeting held in Luxembourg, 30 Aug. - 1 Sep. 1989
(AGARD-CP-469; ISBN-92-835-0544-1) Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The Specialists' Meeting was arranged in the following sessions: Basic Flow Phenomena; Experimental Results; Three-Dimensional Computation and Comparison with Experiments; Tip Clearance Flows; and Secondary Flow Effects on Heat Transfer. The Technical Evaluation Report is included at the beginning of the proceedings. Questions and answers of the discussions follow each

report. A forum was offered for experts to discuss computational and experimental methods and results of secondary flow in cascades, compressors, and turbines. Computational fluid dynamics was found to be an adequate tool to represent qualitative phenomena, but on the accuracy of predicting losses and exit angles there was some disagreement. Many papers dealt with experimental investigations which are obviously essential for evaluating secondary flow models.

N90-21010# Vrije Univ., Amsterdam (Netherlands). Dept. of Fluid Mechanics.

SECONDARY FLOWS AND RADIAL MIXING PREDICTIONS IN AXIAL COMPRESSORS

J. DERUYCK, CH. HIRSCH, and P. SEGAERT *In* AGARD, Secondary Flows in Turbomachines 19 p Feb. 1990 Sponsored in part by AFOSR, Bolling AFB, Washington, DC and IWONL, Brussels, Belgium

 Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

A radial mixing computation method is presented in the framework of an integrated quasi-3D approximation method for turbomachinery flow computations. The radial mixing computation is performed on a transverse surface S3, the only type of stream surface hitherto not considered in the quasi-3D computation. Both convective and diffusive mixing mechanisms are taken into account: the convective mixing due to secondary flows is computed explicitly, while the diffusive mixing due to the random effects of turbulence is modeled by empirical coefficients. The flow field on the S3-surface is reconstructed from the knowledge of axial vorticity contributions for different flow regions, which are added to constitute the right-hand side of a quasi-harmonic Poisson-type stream function equation. These axial vorticity components are obtained through vorticity equations for the inviscid flow region, combined with integral methods for the 3D end-wall boundary layers, 3D profile boundary layers, and 3D asymmetric wakes. The validity of the secondary flow computation is assessed through comparisons between computational results and experimental data. The method is applied to predict the redistribution of radial temperature profiles for three axial turbomachines: a linear cascade and two single-stage compressor rotors. Author

N90-21011# United Technologies Research Center, East Hartford, CT.

THE EFFECTS OF COMPRESSOR ENDWALL FLOW ON AIRFOIL INCIDENCE AND DEVIATION

ROBERT P. DRING and H. DAVID JOSLYN *In* AGARD, Secondary Flows in Turbomachines 9 p Feb. 1990

 Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

A previous examination of through flow theory in compressors has demonstrated that while there are many ways to define the average flow angle at a particular span location downstream of an airfoil, only one definition is consistent with the formulation of through flow theory. It was also demonstrated that the flow in the endwall regions is especially sensitive to this question due to the strong secondary flows and the hub corner separations that commonly occur. The question of how these observations may be extended to the airfoil-to-airfoil flow analysis is examined. It is demonstrated that the question of the correct average can have a strong impact on both airfoil incidence and deviation. Differences of up to 13 degrees are demonstrated. It is also suggested that one specific angle definition results in better predictions of airfoil pressure distributions. Author

N90-21012# Middle East Technical Univ., Ankara (Turkey). Dept. of Mechanical Engineering.

A STUDY ON SECONDARY FLOW AND SPANWISE MIXING IN AXIAL FLOW COMPRESSORS

MURAT ERKILET and AHMET S. UCER *In* AGARD, Secondary Flows in Turbomachines 10 p Feb. 1990

 Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Axisymmetric throughflow equations are reformulated in order to introduce the effect of spanwise mixing in axial flow compressors. The spanwise mixing model used in this investigation assumes that turbulent diffusion is the dominant physical mechanism for the onset of spanwise mixing rather than the deterministic nature of secondary flow model. Two-dimensional loss and deviation correlations available in the open literature are used together with the 3-D, secondary flow loss models for middle stages. End-wall boundary layer blockage is either introduced from experimental data if available or calculated using simple models. Finite element method is used for the solution of the equation of motion. Author

N90-21014# Motoren- und Turbinen-Union Muenchen G.m.b.H. (Germany, F.R.).

EXPERIMENTAL AND NUMERICAL STUDY ON BASIC PHENOMENA OF SECONDARY FLOWS IN TURBINES

R. NIEHUIS, P. LUECKING, and B. STUBERT *In* AGARD, Secondary Flows in Turbomachines 17 p Feb. 1990 Sponsored by the Germany Ministry for Research and Technology

 Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The recent understanding and the basic principles of secondary flow development in turbines, such as the formation of a horseshoe vortex and a passage vortex, are illustrated. Results are obtained for an experimental investigation of the three-dimensional flow within an annular cascade rig of an inlet guide vane of a low pressure turbine. Flow calculations with a three dimensional Euler and a partially parabolized Navier-Stokes code were performed, and the numerical results are discussed and compared with the experiment. Additionally, the computer codes were applied to calculate the three dimensional flow within two different model configurations designed to expose the influence and the contribution of different secondary flow phenomena in the end wall region. Author

N90-21015# Brescia Univ. (Italy). Dept. di Meccanica.

SECONDARY FLOWS AND REYNOLDS STRESS DISTRIBUTIONS DOWNSTREAM OF A TURBINE CASCADE AT DIFFERENT EXPANSION RATIOS

ANTONIO PERDICHIZZI, MARINA UBALDI, and PIETRO ZUNINO (Genoa Univ., Italy) *In* AGARD, Secondary Flows in Turbomachines 13 p Feb. 1990

 Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The results are presented for an experimental investigation on secondary flows and turbulence in a plane located 30 percent of an axial chord downstream of a turbine cascade. Mean velocity field, energy loss, and Reynolds stress distributions were measured with pressure and hot-wire probes at different expansion ratios for three isentropic outlet Mach numbers M(sub 2is) = 0.3, 0.5, and 0.7. High levels of turbulence kinetic energy are found in the passage-shed vortex interaction region and in the corner vortex, while lower values are present in the wake. The turbulent shear stress distributions, analyzed in detail, are consistent with the mean strain field. As the Mach number increases, the turbulence kinetic energy level is significantly reduced. The bar UV and bar vw shear stresses show a similar trend, while the bar uw component remains the same magnitude, revealing different contributions to the dissipation rate. Author

N90-21016# Durham Univ. (England). School of Engineering and Applied Science.

AN INVESTIGATION OF SECONDARY FLOWS IN NOZZLE GUIDE VANES

R. G. DOMINY and S. C. HARDING (Rolls-Royce Ltd., Bristol, England) *In* AGARD, Secondary Flows in Turbomachines 15 p Feb. 1990 Sponsored by the British Science and Engineering

Research Council
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Much of the energy loss that occurs in turbine nozzles is associated with the strongly three dimensional secondary flows that result from the interaction between the surface boundary layers and the nozzle row with its associated pressure field. Three alternative nozzles, each performing the same duty, with different degrees of three dimensionality in their designs to control secondary flow are studied. The chosen nozzle guide vanes are fully representative of the current generation of high hub-tip ratio aero engine nozzles in which the proportion of the overall loss that is attributable to secondary flows is high. A computational analysis of all three nozzles is presented including predictions from three alternative viscous, three dimensional methods. These detailed measurements and predictions demonstrate the significant influence of the vane geometries on the magnitude and the distribution of the secondary losses. Author

N90-21017# Royal Aerospace Establishment, Farnborough (England). Propulsion Dept.
SECONDARY FLOW PREDICTIONS FOR A TRANSONIC NOZZLE GUIDE VANE
G. C. HORTON *In* AGARD, Secondary Flows in Turbomachines 12 p Feb. 1990
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

To improve turbine efficiency it is necessary to design the blading to control the flow, including the secondary flow, and hence reduce the losses. A method is therefore required to predict the three-dimensional flow, with losses, within turbine geometries. Three-dimensional viscous flow programs offer the capability of doing this. Such a program (as developed by Dawes) is available at the Royal Aerospace Establishment, Pyestock. It was used to analyze the flow through a transonic turbine nozzle guide vane which was tested in cascade at Pyestock. The predictions are compared with surface pressure and downstream traverse results to assess the ability of the program to predict secondary flows and losses in a highly loaded nozzle guide vane operating at representative engine conditions. Author

N90-21018# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne (Germany, F.R.). Inst. fuer Antriebstechnik.
SECONDARY FLOW IN A TURBINE GUIDE VANE WITH LOW ASPECT RATIO
D. WEGENER, J. QUEST, and W. HOFFMANN *In* AGARD, Secondary Flows in Turbomachines 9 p Feb. 1990
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The flow field of an annular turbine cascade with low aspect ratio (0.6) is investigated by means of experiments and numerical calculations. An advanced computer code was applied to solve the three dimensional Reynolds averaged Navier-Stokes equations. Detailed measurements with 5-hole probes and an advanced Laser-Two-Focus velocimeter (L2F) were carried out to evaluate the numerical solution of the flow field. Flow visualization on the endwalls and on the blade surfaces complement the experimental data and help to understand the secondary flow phenomena. The results show that this 3D-NS calculation is an efficient tool to predict complex secondary flow phenomena. Author

N90-21019# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Inst. fuer Experimentelle Stroemungsmechanik.
MEASUREMENT OF THE FLOW FIELD IN THE BLADE PASSAGE AND SIDE-WALL REGION OF A PLANE TURBINE CASCADE
E. DETEMPLE-LAAKE *In* AGARD, Secondary Flows in Turbomachines 13 p Feb. 1990
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The transonic flow through a plane cascade consisting of profiles designed for a highly loaded gas turbine rotor of a high pressure stage is investigated. The experiments presented are part of an entire test program performed in a special wind tunnel at the DLR. The measurements of the side-wall pressure distribution in a blade passage are described. The parameters varied are the inlet flow angle and the downstream isentropic Mach number. Based on the results of Schlieren photographs of the flow field and suface oil flow patterns on the blades and the side-wall, the experimental results are interpreted. Author

N90-21020# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne (Germany, F.R.). Inst. fuer Antriebstechnik.
CENTRIFUGAL IMPELLER GEOMETRY AND ITS INFLUENCE ON SECONDARY FLOWS
H. KRAIN and W. HOFFMANN *In* AGARD, Secondary Flows in Turbomachines 17 p Feb. 1990
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Detailed experimental and theoretical flow field studies are carried out for two 30 degree, high pressure ratio impellers having the same blade geometry but different shroud contours. An advanced Laser-Two-Focus Velocimeter is used to obtain experimental data. The theoretical investigations are performed with a 3D-viscous code that was coupled with a postprocessor primarily suitable for turbomachinery flow field studies. Comparisons between measured and calculated data are carried out and the influence of the flow channel variation on the through flow velocity patterns and secondary flow structures are discussed. Author

N90-21021# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
CALCULATION OF THE THREE DIMENSIONAL TURBULENT FLOW IN A LINEAR TURBINE BLADE [CALCUL DE L'ECOULEMENT TRIDIMENSIONNEL TURBULENT DANS UN AUBAGE RECTILIGNE DE TURBINE]
L. CAMBIER and B. ESCANDE *In* AGARD, Secondary Flows in Turbomachines 15 p Feb. 1990 In FRENCH; ENGLISH summary
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The numerical simulation of a three-dimensional turbulent flow in a linear turbine cascade, is examined by solution of the Reynolds-averaged compressible Navier-Stokes equations with an algebraic turbulence model. The numerical method is characterized by an explicit centered finite difference scheme, associated with a multigrid convergence acceleration. The splitting of the computational domain in an 0-type subdomain around the blade and two H-type subdomains upstream and downstream allows an accurate description of the round leading edges and trailing edges, while setting the upstream and downstream boundaries of the domain sufficiently far from the blade. The results obtained in a mesh containing more than 300,000 points (in a domain bounded by a symmetry plane) show complex phenomena of secondary flows, qualitatively similar to the phenomena observed in an experiment carried out at a lower flow velocity. Author

N90-21022# Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Moissy-Cramayel (France).
CALCULATION OF THE SECONDARY FLOW IN AN AXIAL TURBINE [CALCUL DES ECOULEMENTS SECONDAIRES DANS UNE TURBINE AXIALE]
J. BERNARD and F. FALCHETTI *In* AGARD, Secondary Flows in Turbomachines 12 p Feb. 1990 In FRENCH; ENGLISH summary
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Satisfactory prediction of secondary flow effects can be considered a major objective in the design and analysis of turbine blades. A method, initially developed for the computation of secondary flows in multi-stage compressors, is briefly presented together with results obtained on a turbine nozzle cascade and on a low pressure turbine stage. Satisfactory results are obtained for the secondary vorticity as well as for the local variations in the velocity triangles. However, secondary losses and blockage are not well predicted due to the integral character of the wall boundary layer calculation used in the model. However, use of the method together with current correlations can yield interesting results especially as far as successive blade row adaptation is concerned. For detailed predictions of blade row performance, in particular secondary flow effects, the turbine designer must implement more complex methods developed for the resolution of the three-dimensional Navier-Stokes equations. Author

N90-21023# General Electric Co., Schenectady, NY. Corporate Research and Development.
GENERATION AND DECAY OF SECONDARY FLOWS AND THEIR IMPACT ON AERODYNAMIC PERFORMANCE OF MODERN TURBOMACHINERY COMPONENTS
C. HAH *In* AGARD, Secondary Flows in Turbomachines 13 p Feb. 1990
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A three-dimensional viscous flow code is used to distinguish aerodynamic performance of different designs of turbomachinery components. Two designs of a high-pressure-ratio turbine nozzle and a centrifugal compressor impeller are numerically studied to investigate detailed flow development and overall aerodynamic performance. It is indicated that the current viscous code can differentiate aerodynamic performance of various designs of turbomachinery components. Author

N90-21024# National Technical Univ., Athens (Greece). Lab. of Thermal Turbomachines.
SECONDARY FLOW CALCULATIONS FOR AXIAL AND RADIAL COMPRESSORS
D. DOUVIKAS, J. KALDELLIS, and K. D. PAPAILIOU *In* AGARD, Secondary Flows in Turbomachines 17 p Feb. 1990
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

A secondary flow calculation method is presented, the development of which was recently completed in the Thermal Turbomachinery Laboratory of the National Technical University of Athens. This method makes use of the meridional vorticity transport equation, the momentum integral equation, and the mean kinetic energy integral equation. Emphasis is placed upon the use of a coherent two-zone model and care is taken to describe adequately the flow inside an unbounded (external), semi-bounded (annulus), and fully-bounded (bladed) space. The hub and tip secondary flow development is calculated simultaneously, so that, the use of an approximate model for the interaction between the viscous shear layer and the external flow, permits this last flow field to be adapted to the growth of the wall shear layers during the computational procedure. Not only the meridional but also the peripheral blockage is taken into account during this procedure. An additional approximate viscous-inviscid interaction model is used, when shocks are present in the passage. An attempt is made to place the method in historical perspective. Then, after its brief discription, comparisons with experimental results are presented along with the appropriate discussion in order to evaluate the capabilities of the method. Author

N90-21025*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE NUMERICAL SIMULATION OF MULTISTAGE TURBOMACHINERY FLOWS
J. J. ADAMCZYK, T. A. BEACH, M. L. CELESTINA, R. A. MULAC, and W. M. TO (Sverdrup Technology, Inc., Cleveland, OH.) *In* AGARD, Secondary Flows in Turbomachines 13 p Feb. 1990
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The need to account for momentum and energy transport by the unsteady deterministic flow field in modeling the time-averaged flow state within a blade row passage embedded in a multistage compressor is assessed. It was found that, within the endwall regions, large-scale three-dimensional unsteady structures existed which caused significant transport of momentum and energy across the time-averaged stream surface of a stator flow field. These experiments confirmed that the tranport process is dominated by turbulent diffusion in the midspan region. A model was then proposed for simulating this transport process, and a limited study was undertaken to assess its validity. Author

N90-21026# Connecticut Univ., Storrs. Dept. of Mechanical Engineering.
RESEARCH ON CASCADE SECONDARY AND TIP-LEAKAGE FLOWS: PERIODICITY AND SURFACE FLOW VISUALIZATION
L. S. LANGSTON *In* AGARD, Secondary Flows in Turbomachines 15 p Feb. 1990
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Large scale planar cascade experimental studies were used for some years now to sort out and measure three-dimensional flows in axial flow turbines. In particular, these planar cascades were and are used for secondary flow studies and more recently for tip clearance studies. Cascade periodicity and the use of surface flow visualization in planar turbine cascades, in these studies are the topics of focus. Since results from these cascade experimental studies are based on a planar casade that usually has few airfoils, the topic of how periodicity is achieved in a finite cascade is an important one. One method of achieving periodicity in a 4-airfoil cascade is discussed. The use of surface flow visualization in these cascade studies has benn prominent. A commetary is given on three techniques that were used, and on the interpretation of the results from each technique. Author

N90-21027# Carleton Univ., Ottawa (Ontario). Dept. of Mechanical and Aerospace Engineering.
LOSSES IN THE TIP-LEAKAGE FLOW OF A PLANAR CASCADE OF TURBINE BLADES
M. I. YARAS and S. A. SJOLANDER *In* AGARD, Secondary Flows in Turbomachines 13 p Feb. 1990 Sponsored in part by Pratt and Whitney Canada, Inc.
(Contract NSERC-A1671)
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The total pressure losses in the tip-leakage flow of a planar cascade of turbine blades are examined. The objective is to clarify the loss mechanisms which affect the tip gap flow as well as to provide additional data on tip-leakage losses for use in correlations. Clearances of 1.5 to 5.5 percent of the blade chord are considered. The flow was measured also for zero clearance to identify the conventional secondary flow component of the loss. The data presented clarify the role played in the evolution of the tip-leakage losses by: the viscous stresses and separation bubbles inside the tip gap; the sudden expansion as the flow emerges from the gap; and the mixing out process as the tip-leakage vortex develops downstream of the trailing edge. The direct loss within the clearance gap is found to be relatively unimportant for the full range of clearances. The measurements are compared with commonly-used correlations for the tip-leakage losses. Author

N90-21028# Technische Hochschule, Aachen (Germany, F.R.). Inst. fuer Strahlantriebe und Turboarbeitsmaschinen.
COMPUTATIONAL PREDICTION AND MEASUREMENT OF THE FLOW IN AXIAL TURBINE CASCADES AND STAGES
H. E. GALLUS, K. WESKAMP, and J. ZESCHKY *In* AGARD, Secondary Flows in Turbomachines 10 p Feb. 1990

 Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

A partially-parabolic program was developed to calculate the three-dimensional, viscous flow through subsonic axial turbine guide vanes and rotor blades. To provide test cases for the calculations, a detailed experimental study of the flow in an axial turbine stage as well as in an axial-flow turbine cascade was performed. The obtained results and the comparison of the theoretical and experimental data are discussed. Author

N90-21029# Technische Hochschule, Aachen (Germany, F.R.). Inst. for Jet Propulsion and Turbomachinery.

ANALYSIS OF THE ROTOR TIP LEAKAGE FLOW WITH TIP COOLING AIR EJECTION

W. KOSCHEL, H. SCHMIDT, and A. VORNBERGER *In* AGARD, Secondary Flows in Turbomachines 14 p Feb. 1990 Sponsored by Deutsche Forschungsgemeinschaft

 Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

A numerical simulation of turbine rotor tip leakage flow was carried out taking into account tip coolant flow injection. The numerical scheme is based on a finite element method for the integration of the Navier-Stokes equations in the conservative form using an explicit two-step Taylor-Galerkin algorithm. The application of unstructured grids together with local refinement strategies allows a detailed resolution of viscous flow phenomena in the clearance gap. The analysis is performed for an HP turbine blade with a tip groove without and with tip coolant flow injection. The effect of varying clearance height and of wall motion is also considered. Results on 2D-flow computations are presented and discussed in regard to viscous flow effects and to the relative mass flow discharge in the tip clearance for the different investigated configurations. Author

N90-21033# National Research Council of Canada, Ottawa (Ontario). Gas Dynamics Lab.

THE EFFECT OF SECONDARY FLOW ON THE REDISTRIBUTION OF THE TOTAL TEMPERATURE FIELD DOWNSTREAM OF A STATIONARY TURBINE CASCADE

W. E. CARSCALLEN and P. H. OOSTHUIZEN (Queens Univ., Kingston, Ontario) *In* AGARD, Secondary Flows in Turbomachines 18 p Feb. 1990

 Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Early testing at the National Research Council of Canada's (NRCC) Highly Loaded Turbine Test Rig revealed that the total temperature downstream of a turbine nozzle was redistributed relative to the nozzle inlet total temperature distribution and furthermore there was an apparent change in area averaged total temperature across the stator row. In order to examine these observations a transonic planar cascade of the exhauster type was constructed at NRCC. Tests were carried out at pressure ratios giving nozzle isentropic exit Mach numbers ranging from low subsonic to low supersonic. Wedge probes were used to measure total pressure, total temperature, and flow angles downstream of the nozzle blade. Test results indicated that the exit total temperature distributions are highly redistributed and possible reasons for this phenomena are discussed. Results of area averaged aerodynamic losses are also given and their relation to the change in total temperature across the nozzle blades are discussed. Author

N90-21034 Oklahoma Univ., Norman.

PERFORMANCE OF AN AERO-SPACE PLANE PROPULSION NOZZLE Ph.D. Thesis

YOON-YEONG BAE 1989 135 p Previously announced in IAA as A89-42103

Avail: Univ. Microfilms Order No. DA9003663

An inviscid and viscous analysis is provided for an exposed half nozzle that is used with a scramjet for thrust generation. The analysis is based on the inviscid theory of a 2-D, minimum length nozzle with a curved inlet surface, where the flow may be sonic or supersonic. Inlet conditions are prescribed and the gas is assumed to be perfect. Viscous, and when appropriate inviscid, nondimensional parametric results are provided for the thrust, lift, heat transfer, pitching moment, and a variety of boundary layer thicknesses. In addition to global results, wall distributions of pressure, heat transfer, etc., are provided. The analysis demonstrates that the nozzle produced a considerable lift force whose magnitude may exceed the thrust and a significant pitching moment. The thrust is quite sensitive to the inlet Mach number; it rapidly decreases as the inlet Mach number increases. There is little loss in the thrust as the nozzle's downstream wall is truncated. The corresponding decrease in lift and the pitching moment is moderate. Dissert. Abstr.

N90-21035 Council for National Academic Awards (England).

SUPERSONIC NOZZLE DESIGN OF ARBITRARY CROSS-SECTION Ph.D. Thesis

A. HADDAD 1988 201 p

Avail: Univ. Microfilms Order No. BRDX86766

An investigation, both theoretical and experimental in nature, was undertaken to develop a simple method for the design of supersonic nozzles and, indeed, inlets of quite complex shapes from known or calculated axisymmetric flowfields. The axisymmetric flowfield is determined using a computer program based on the method of characteristics. Streamlines are calculated by direct integration of the axisymmetric stream function. The desired shape is chosen at the exit of the computed axisymmetric nozzle having the desired length and Mach number. Its describing points are then traced along the corresponding streamlines back to the throat. Streamsheets formed by these streamlines define the new shape. Following this approach, two three-dimensional nozzles were designed: one of elliptical cross-section and a two-dimensional wedge. Flows within the two configurations were further simulated using a general purpose three-dimensional CFD code, 'PHOENICS' (Parabolic, hyperbolic, or elliptic numerical integration code series), while the elliptical nozzle was subsequently manufactured and submitted to experimental tests. Results from the experimental tests and three-dimensional numerical simulation, as well as predictions of the performance of the nonaxisymmetric nozzles and their axisymmetric counterparts were obtained and compared. Good agreement was achieved between the several components of the study demonstrating that it is possible, using this relatively simple method, to design satisfactory three-dimensional nozzles. Author

N90-21036*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

PROBABILISTIC MODELING FOR SIMULATION OF AERODYNAMIC UNCERTAINTIES IN PROPULSION SYSTEMS

AWATEF HAMED (Cincinnati Univ., OH.) Dec. 1989 28 p (Contract NASA ORDER C-99066-G)

(NASA-TM-102472; ICOMP-89-32; E-5260; NAS 1.15:102472)

Avail: NTIS HC A03/MF A01 CSCL 21/5

The numerical simulation of the probabilistic aerothermodynamic response of propulsion system components to randomness in their environment was explored. The reusable rocket engine turbopumps were selected as an example because of the severe cryogenic environment in which they operate. The thermal and combustion instabilities, coupled with the engine thrust requirements from start up to shut down, lead to randomness in the flow variables and uncertainties in the aerodynamic loading. The probabilistic modeling of the turbopumps aerodynamic response was accomplished using the panel method coupled with fast probability integration methods. The aerodynamic response in the form of probabilistic rotor blades and splitter loading were predicted and the results presented for specified flow coefficient and rotor preswirl variance. Possible future applications of the aerothermodynamic probabilistic modeling in engine transient simulation, condition monitoring and engine life prediction are briefly discussed. Author

N90-21037*# Sverdrup Technology, Inc., Cleveland, OH.
EXHAUST NOZZLES FOR PROPULSION SYSTEMS WITH EMPHASIS ON SUPERSONIC CRUISE AIRCRAFT
LEONARD E. STITT May 1990 107 p
(Contract NAS3-25266)
(NASA-RP-1235; E-4789; NAS 1.61:1235) Avail: NTIS HC A06/MF A01 CSCL 21/5

This compendium summarizes the contributions of the NASA-Lewis and its contractors to supersonic exhaust nozzle research from 1963 to 1985. Two major research and technology efforts sponsored this nozzle research work; the U.S. Supersonic Transport (SST) Program and the follow-on Supersonic Cruise Research (SCR) Program. They account for two generations of nozzle technology: the first from 1963 to 1971, and the second from 1971 to 1985. First, the equations used to calculate nozzle thrust are introduced. Then the general types of nozzles are presented, followed by a discussion of those types proposed for supersonic aircraft. Next, the first-generation nozzles designed specifically for the Boeing SST and the second-generation nozzles designed under the SCR program are separately reviewed and then compared. A chapter on throttle-dependent afterbody drag is included, since drag has a major effect on the off-design performance of supersonic nozzles. A chapter on the performance of supersonic dash nozzles follows, since these nozzles have similar design problems, Finally, the nozzle test facilities used at NASA-Lewis during this nozzle research effort are identified and discussed. These facilities include static test stands, a transonic wind tunnel, and a flying testbed aircraft. A concluding section points to the future: a third generation of nozzles designed for a new era of high speed civil transports to produce even greater advances in performance, to meet new noise rules, and to ensure the continuity of over two decades of NASA research. Author

N90-21038*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SUPERSONIC THROUGH-FLOW FAN ENGINE AND AIRCRAFT MISSION PERFORMANCE
LEO C. FRANCISCUS and JAIME J. MALDONADO (Puerto Rico Univ., Mayaguez.) 1989 15 p Presented at the Aircraft Design, Systems, and Operations Conference, Seattle, WA, 31 Jul. - 2 Aug. 1989; cosponsored by AIAA, AHS, and ASEE
(NASA-TM-102304; E-4991; NAS 1.15:102304; AIAA-89-2139)
Avail: NTIS HC A03/MF A01 CSCL 21/5

A study was made to evaluate potential improvement to a commercial supersonic transport by powering it with supersonic through-flow fan turbofan engines. A Mach 3.2 mission was considered. The three supersonic fan engines considered were designed to operate at bypass ratios of 0.25, 0.5, and 0.75 at supersonic cruise. For comparison a turbine bypass turbojet was included in the study. The engines were evaluated on the basis of aircraft takeoff gross weight with a payload of 250 passengers for a fixed range of 5000 N.MI. The installed specific fuel consumption of the supersonic fan engines was 7 to 8 percent lower than that of the turbine bypass engine. The aircraft powered by the supersonic fan engines had takeoff gross weights 9 to 13 percent lower than aircraft powered by turbine bypass engines.
Author

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A90-33058#
REDUCED-ORDER MODELING AND CONTROLLER DESIGN FOR A HIGH-PERFORMANCE HELICOPTER
MARK EKBLAD (Rockwell International Corp., El Segundo, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, May-June 1990, p. 439-449. Previously cited in issue 22, p. 3656, Accession no. A88-51972. refs
(Contract DAAL03-86-K-0056)
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A90-33060*# Purdue Univ., West Lafayette, IN.
AEROSERVOELASTIC TAILORING FOR LATERAL CONTROL ENHANCEMENT
TERRENCE A. WEISSHAAR and CHANGHO NAM (Purdue University, West Lafayette, IN) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, May-June 1990, p. 458-465. refs
(Contract NSG-1157)
Copyright

The application of an automated optimization approach to the integrated structural and control design of an aircraft wing and its control surface is illustrated. The performance index or cost function for optimization is the aileron hinge moment required to sustain a specified terminal roll rate at a chosen design speed at which aeroelastic effects are significant. The design variables used for aileron hinge-moment minimization are the aileron flap-to-chord ratio; the location of the aileron with respect to the roll axis; and the orientations of three advanced composite plies comprising 60 percent of the wing structure. The effects of aileron location and advanced composite ply orientation on the terminal roll rate and aileron hinge moment are examined. Optimization is seen to involve a compromise between a laminated structure/aileron combination that is effective in creating large rolling moments and one that minimizes the damping-in-roll. These two requirements are in conflict; the optimization driver must locate a compromise design point by moving the control surface and changing its size while also creating a suitable structural design. Author

A90-33061*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
COOPERATIVE SYNTHESIS OF CONTROL AND DISPLAY AUGMENTATION IN APPROACH AND LANDING
SANJAY GARG (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) and DAVID K. SCHMIDT (Purdue University, West Lafayette, IN) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, May-June 1990, p. 466-475. Research supported by Honeywell, Inc. Previously cited in issue 21, p. 3494, Accession no. A88-50272. refs
(Contract NAG4-1; F33615-86-C-3615)
Copyright

A90-33352#
REVIEW OF ACTIVE STRUCTURAL CONTROL SYSTEMS AND FLIGHT TEST TECHNIQUES FOR DYNAMIC STABILITY INVESTIGATIONS
OTTO SENSBURG (MBB GmbH, Munich, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 1-14. refs

Aircraft dynamic response to atmospheric turbulence is analyzed by employing a noncylindrical gust, and load control and alleviation with open-loop and closed-loop flight control systems on an Airbus A300 with extended wings are assessed. It is noted that passive means of gust load alleviation are preferred to active ones because of reduction in maintenance and increase in reliability. Excitation and analysis methods utilized in flight flutter tests are outlined with emphasis on mode separation with a filter correlation technique. The correlation reduces or rejects the truncation effects due to the digital narrow-band filtering in the frequency domain and attenuates the noise. An integrated method for dynamic stability testing of actively controlled aircraft, including servoaeroelastic interactions and dynamic stability, is studied, and dynamic stability test procedures are discussed. V.T.

A90-33401#
MULTI-SURFACE CONTROL LAW SYNTHESIS AND WIND TUNNEL TEST VERIFICATION OF ACTIVE FLUTTER SUPPRESSION FOR A TRANSPORT-TYPE WING
H. MATSUSHITA, Y. MIYAZAWA, T. UEDA, and S. SUZUKI (National Aerospace Laboratory, Tokyo, Japan) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 521-527. refs

Control laws are synthesized for active flutter suppression of a transport-type high aspect-ratio wing using both the leading-edge and the trailing-edge control surfaces. The LQG optimal control law synthesis method is applied to this multiinput, multioutput system to yield full-order control laws. The order reduction procedure based on chained aggregation, together with some engineering manipulation, establishes the practical low order control laws. This synthesis method is verified effectively by wind tunnel tests. In spite of the violent nature of clean wing flutter, the control law attained 13 percent increase in flutter speed in the test.
Author

A90-33403*# Planning Research Corp., Hampton, VA.
FLUTTER SUPPRESSION CONTROL LAW SYNTHESIS FOR THE ACTIVE FLEXIBLE WING MODEL
VIVEK MUKHOPADHYAY (Planning Research Corp., Hampton, VA), BOYD PERRY, III, and THOMAS E. NOLL (NASA, Langley Research Center, Hampton, VA) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 539-545. Previously announced in STAR as N89-26010. refs

The Active Flexible Wing Project is a collaborative effort between the NASA Langley Research Center and Rockwell International. The objectives are the validation of methodologies associated with mathematical modeling, flutter suppression control law development and digital implementation of the control system for application to flexible aircraft. A flutter suppression control law synthesis for this project is described. The state-space mathematical model used for the synthesis included ten flexible modes, four control surface modes and rational function approximation of the doublet-lattice unsteady aerodynamics. The design steps involved developing the full-order optimal control laws, reducing the order of the control law, and optimizing the reduced-order control law in both the continuous and the discrete domains to minimize stochastic response. System robustness was improved using singular value constraints. An 8th order robust control law was designed to increase the symmetric flutter dynamic pressure by 100 percent. Preliminary results are provided and experiences gained are discussed.
Author

A90-33404#
INTERACTIONS OF ACTIVE CONTROLS AND STRUCTURAL LOADS
I. V. KAYNES (Royal Aerospace Establishment Farnborough, England) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 547-555. refs

An integrated approach to the design of active control systems for aircraft is desirable. However, single objective implementations of active controls can have undesirable effects on flight loads and these effects must be understood and included in the cost function of integrated design methods. In this paper this subject is discussed with reference to examples of the structural implications of some flight control systems. The design of a ride control system on a combat aircraft is considered. There are shown to be a range of objectives which can be invoked for the primary ride control function, such as the root mean square or frequency of occurrence of responses. Examining the consequent structural loads shows that there is an even wider range of significant load assessments to be made. Some detrimental loading actions can be alleviated by redesigning the control system but with only small detrimental effects on performance of the primary control task.
Author

A90-33405*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN ANALYTICAL SENSITIVITY METHOD FOR USE IN INTEGRATED AEROSERVOELASTIC AIRCRAFT DESIGN
MICHAEL G. GILBERT (NASA, Langley Research Center, Hampton, VA) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 557-565. Previously announced in STAR as N89-25239. refs

Interdisciplinary analysis capabilities have been developed for aeroservoelastic aircraft and large flexible spacecraft, but the requisite integrated design methods are only beginning to be developed. One integrated design method which has received attention is based on hierarchal problem decompositions, optimization, and design sensitivity analyses. This paper highlights a design sensitivity analysis method for Linear Quadratic Gaussian (LQG) optimal control laws, enabling the use of LQG techniques in the hierarchal design methodology. The LQG sensitivity analysis method calculates the change in the optimal control law and resulting controlled system responses due to changes in fixed design integration parameters using analytical sensitivity equations. Numerical results of an LQG design sensitivity analysis for a realistic aeroservoelastic aircraft example are presented. In this example, the sensitivity of the optimal control law and aircraft response for various parameters such as wing bending natural frequency is determined. The sensitivity results computed from the analytical expressions are used to estimate changes in response resulting from changes in the parameters. Comparisons of the estimates with exact calculated responses show they are reasonably accurate for + or - 15 percent changes in the parameters. Evaluation of the analytical expressions is computationally faster than equivalent finite difference calculations.
Author

A90-33406#
IMPLEMENTATION OF COMPREHENSIVE ACTUATION SYSTEM MODELS IN AEROSERVOELASTIC ANALYSIS
R. STIRLING (Stirling Dynamics, Ltd., Bristol, England) and D. A. COWLING (Bristol, University, England) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 567-576.

The overall validity of an aeroservoelastic model is dependent on the separate validities of its components, i.e. the airframe and aerodynamics, the control system, and the actuation system. All of these component models must be accurate over a consistent frequency range. It is usual to represent actuator response to commands by means of a transfer function, and impedance by a linear spring of appropriate stiffness. In order to ensure that the actuation system representations meet the validity requirements, and to keep pace with advances in modeling technique in the other components, it is desirable to introduce detailed actuator models based on their electrical, hydraulic and mechanical characteristics, including complex impedance effects. The manner in which this can be achieved is described for evaluation of stability roots, frequency response and time response. Nonlinear actuation and control system features can be accommodated in the time domain analysis. Results are shown for a gust alleviation system in an advanced combat aircraft with a canard/delta configuration, using three control surfaces.
Author

A90-33413#
FAST CALCULATION OF ROOT LOCI OF AEROELASTIC SYSTEMS AND OF GUST RESPONSE IN TIME DOMAIN
J. BRINK-SPALINK and J. WITTE (MBB GmbH, Hamburg, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 643-646. refs

A derivation is presented of optimal time discretizations of equations of motions for response calculations of aeroelastic systems. For the approximations of aerodynamic matrices, a problem-dependent error measure is given, which involves the excitation, transfer, and output variables of interest. A new fast method is presented for calculations of the root loci of aeroelastic systems, which is based on interpolation of determinants instead of matrix elements. The determinants involved are computed, at low computer cost, from Hessenberg matrices. I.S.

A90-33622
MANEUVER PERFORMANCE COMPARISON BETWEEN THE XV-15 AND AN ADVANCED TILTROTOR DESIGN
JOHN J. SCHILLINGS, BRADFORD J. ROBERTS, TOMMIE L. WOOD, and KENNETH G. WERNICKE (Bell Helicopter Textron, Inc., Fort Worth, TX) American Helicopter Society, Journal (ISSN 0002-8711), vol. 35, April 1990, p. 4-14. refs
Copyright

This paper presents the maneuver performance, rotor and airframe aerodynamic capabilities, and rotor maneuvering loads as measured during the XV-15 flight test program. Correlation is shown with analysis to establish the basis for maneuver capability predictions of tiltrotor variants. An advanced tiltrotor design is presented which demonstrates agility and maneuverability for air-to-air combat and gunship-type missions. The new design, which is called the Super XV-15, applies advanced aerodynamic and structural technology which is being used on the V-22 Osprey. The XV-15 and Super SV-15 are compared on the basis of aerodynamic capability, control response, rotor loads, acceleration and deceleration capability, and maximum rate of climb. Author

A90-33623* Florida Atlantic Univ., Boca Raton.
AN EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF ISOLATED ROTOR FLAP-LAG STABILITY IN FORWARD FLIGHT
GOPAL H. GAONKAR (Florida Atlantic University, Boca Raton), MICHAEL J. MCNULTY (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), and J. NAGABHUSHANAM (Indian Institute of Science, Bangalore, India) American Helicopter Society, Journal (ISSN 0002-8711), vol. 35, April 1990, p. 25-34. refs
(Contract NCC2-361; DAAL03-87-K-0037)
Copyright

The flap-lag stability of an isolated hingeless rotor is investigated, both experimentally and analytically, in hover and in forward flight. The effects of forward flight aerodynamics on regressing lead-lag mode stability are the focus of the investigation. The soft-inplane, three-bladed, isolated model rotor was operated untrimmed at advance ratios from hover to 0.55 and at shaft angles as high as 20 deg. The experimental data base includes forward flight damping data for two lead-lag natural frequencies, for three values of collective pitch, and for both zero and full-lag structural coupling. With the aid of computerized symbolic manipulation, a rigid-blade lag-flap model analysis was developed to calculate the Floquent eigenvalues and to identify the modes. Good correlation is shown for some cases, but other cases show large discrepancies between the theory and experiment. Author

A90-33625
HELICOPTER RESPONSE TO ATMOSPHERIC TURBULENCE IN FORWARD FLIGHT
ANDREW S. ELLIOTT and INDERJIT CHOPRA (Maryland, University, College Park) American Helicopter Society, Journal (ISSN 0002-8711), vol. 35, April 1990, p. 51-59. refs
(Contract DAAG29-83-K-0002)
Copyright

The response of a helicopter rotor-body system in forward flight to a nonstationary random gust field is examined analytically, using a state space formulation in the time domain. The statistically sufficient characteristics of the nonstationary response, namely the mean vector and covariance matrix, are obtained by direct time integration of the stochastic differential equations. Threshold crossing and peak value statistics are derived for arbitrary threshold levels. The hingeless rotor blades are modelled structurally as rotating elastic beams, while the hub and fuselage are considered as a single rigid body. The aerodynamic forcing is developed using a two-dimensional unsteady aerodynamic model with compressibility effects included. The external environment consists of a uniform free-stream velocity, plus a one-dimensional, nonstationary, Gaussian stochastic perturbation with known mean and standard deviation and von Karman power spectral density distribution. Results are presented for a model helicopter at various combinations of advance ratio, turbulence intensity, and scale length typical of low altitude and nap-of-the-earth flight environments. Nonstationarity in the gust field is shown to have little effect on the response, while choice of altitude and airspeed may significantly alter the hub and blade motions. Author

A90-33895#
TEN YEARS OF STALL TESTING
PETE REYNOLDS (Learjet Corp., Wichita, KS) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 78-89.
(AIAA PAPER 90-1268) Copyright

A ten-year-long, four-campaign flight test program has been used by a business jet manufacturer to arrive at a series of simple, relatively inexpensive aerodynamic modifications that improved aircraft stall dynamics characteristics over the range of possible maneuvering conditions. The primary problem to be dealt with was the leading-edge stall associated with thin-section supercritical airfoils in the absence of leading-edge flaps or stall-control devices. Stall strips, wing fences, and wing leading-edge triangles have all proven effective in tailoring stall characteristics, although their effects are highly dependent on specific aircraft configuration. O.C.

A90-33900#
EQUATION DECOUPLING - A NEW APPROACH TO THE AERODYNAMIC IDENTIFICATION OF UNSTABLE AIRCRAFT
HARALD PREISSLER and HORST SCHAEUFELE (MBB GmbH, Munich, Federal Republic of Germany) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 126-134.
(AIAA PAPER 90-1276) Copyright

This paper presents the equation decoupling technique as a new approach to the Parameter Estimation of both aerodynamically stable and unstable aircraft via the output error method. It is shown, that this technique not only eliminates the numerical difficulties of integrating the unstable system and sensitivity equations, but also leads to a considerable reduction of CPU time consumption. Simulated data of an advanced, aerodynamically unstable combat aircraft study, obtained from a nonlinear six degree of freedom simulation, are used to illustrate the technique. Nondimensional Derivatives are estimated, using both linear and nonlinear kinematic models of the aircraft, and a comparison of the results with the corresponding reference data from the aerodynamic data set is performed. It is concluded, that the equation decoupling technique is an efficient tool for parameter estimation purposes in flight test environments at both aerodynamically stable and unstable aircraft. Author

A90-33901*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
ESTIMATING SHORT-PERIOD DYNAMICS USING AN EXTENDED KALMAN FILTER
JEFFREY E. BAUER (NASA, Flight Research Center, Edwards, CA) and DOMINICK ANDRISANI (Purdue University, West Lafayette, IN) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 135-169. refs
(AIAA PAPER 90-1277) Copyright

An extended Kalman filter is used to estimate the parameters

of a low-order model from aircraft transient response data. The low-order model is a state-space model derived from the short-period approximation of the longitudinal aircraft dynamics. The model corresponds to the pitch rate to stick force transfer function currently used in flying qualities analysis. The parameters are estimated from flight data as well as from a 6-DOF nonlinear simulation of the aircraft. These two estimates are then compared, and the discrepancies noted. The low-order model is able to satisfactorily match both flight data and simulation data from a high-order computer simulation. Author

A90-33906#
TECHNIQUES FOR IMPROVING PRECISION OF FLYING QUALITIES ASSESSMENT
ROBERT K. HEFFLEY (Robert Heffley Engineering, Los Altos, CA) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 206-214. refs
(AIAA PAPER 90-1285) Copyright

As flight test task performance requirements are increased, there may initially be little effect on pilot workload; in due course, however, a threshold is reached at which such effects become significant. Examples of this are presently discussed for the cases of helicopter nap-of-the-earth and air combat maneuvering tasks, as well as for a fixed-wing aircraft's carrier landing. In all cases, the time required for a vehicle to respond can be directly related to the time available, as defined by task or maneuver constraints. This fact furnishes a useful basis for the assessment of handling qualities having time-response implications. O.C.

A90-33907#
USE OF GROUND-BASED AND IN-FLIGHT SIMULATION FOR FLIGHT CONTROL SYSTEM DEVELOPMENT
MICHAEL PARRAG, LOUIS KNOTTS, and NORMAN WEINGARTEN (Calspan Advanced Technology Corp., Buffalo, NY) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 215-224.
(AIAA PAPER 90-1286) Copyright

Modern aircraft design requirements have resulted in highly augmented configurations where there is a need to test with a pilot-in-the-loop to resolve critical design issues. A historical background on the evolution of ground-based and in-flight simulators and the manner in which they are now used in the development of flight control systems is presented. Possible inadequacies or advantages of various types of simulation are discussed. A process for designing flight control systems through complementary use of ground-based and in-flight simulators is recommended in order to provide better evaluations of the flying qualities of the closed loop pilot-aircraft combination. Author

A90-33918#
FLIGHT TESTING FOR AIRCRAFT AGILITY
STUART L. BUTTS and ALAN R. LAWLESS (USAF, Flight Test Center, Edwards AFB, CA) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 317-328. refs
(AIAA PAPER 90-1308)

The assumptions underlying the concept of agility are that (1) there exists a definable set of characteristics that can be used as an aide in predicting a fighter aircraft's effectiveness in air combat, and (2) this set of characteristics can be used to specify design evaluation, and tactical utility criteria. The concept of agility has evolved as a result of deficiencies in traditional measures of merit for adequately predicting fighter aircraft effectiveness in the modern air combat arena. Aircraft agility is the ability to change aircraft attitude and flight path with quickness and precision. Measures of merit and flight test techniques for quantifying aircraft agility have been developed. Author

A90-33926*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A SUMMARY OF SPIN-RECOVERY PARACHUTE EXPERIENCE ON LIGHT AIRPLANES
H. PAUL STOUGH, III (NASA, Langley Research Center, Hampton, VA) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 393-402. refs
(AIAA PAPER 90-1317) Copyright

From 1977 to 1989, the NASA Langley Research Center conducted stall/spin flight tests of variations of four typical light airplanes. Each was equipped with an identical tail-mounted, spin-recovery parachute system. The system was used 29 times to arrest otherwise unrecoverable spins and was used at least twice on each airplane. The 10.5 ft diameter, ring-slot, spin-recovery parachute with 20 ft attachment lines and drag coefficient of .545 provided recovery from spins at angles of attack of 32 to 79 degrees and rotation rates of 122 to 261 degrees per second in less than 3 1/2 turns. Author

A90-33931#
DIGITAC - A UNIQUE DIGITAL FLIGHT CONTROL TESTBED AIRCRAFT
E. ROBERT LEMBLE (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) AIAA, SFTE, DGLR, and SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990. 15 p.
(AIAA PAPER 90-1288)

The DIGITAC YA-7D program including the most recent HAVE COUPLING special project is discussed. This project investigates the handling qualities degradation that occurs during flight when a single pitch control surface is impaired causing an unsymmetric control situation that produces roll and yaw cross coupling motion when pitch only motion is commanded by the pilot. One significant finding of the HAVE COUPLING project was that with exactly the same amounts of cross coupling present, the handling qualities ratings during inflight simulation were found to be substantially different then the pilot ratings obtained in ground based simulation. R.E.P.

A90-34082
RESPONSE CHARACTERISTICS OF A TWO-DIMENSIONAL WING SUBJECTED TO TURBULENCE NEAR THE FLUTTER BOUNDARY
Y. MATSUZAKI and H. TORII (Nagoya University, Japan) Journal of Sound and Vibration (ISSN 0022-460X), vol. 136, Jan. 22, 1990, p. 187-199. refs
Copyright

Subcritical flutter characteristics are examined by using a simple bending-torsion wing model subjected to flow turbulence with a view to application for flutter boundary prediction. The wing response due to random inputs is represented by the autoregressive moving-average model. Wing stability is evaluated with the aid of Jury's stability criterion. Jury's stability parameters are expressed in terms of the physical quantities of the deterministic aeroelastic model. Change in the stability parameters is compared with that of model dampings in the subcritical range. According to numerical results, the flutter boundary prediction by using Jury's criterion is more useful than the conventional damping method. Variances of the estimated stability parameters are calculated at several dynamic pressures to evaluate how scattering of the estimation changes. As the dynamic pressure approaches the flutter boundary, the variance of the estimated value of the parameter which predicts the boundary decreases monotonically as was observed in a previous experiment made by the senior author of the present paper. For the estimation of the flutter boundary, it is highly recommended to use the ARMA model rather than the AR model. Author

A90-34149*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
FLIGHT-TESTING OF THE SELF-REPAIRING FLIGHT CONTROL SYSTEM USING THE F-15 HIGHLY INTEGRATED DIGITAL ELECTRONIC CONTROL FLIGHT RESEARCH FACILITY
JAMES F. STEWART and THOMAS L. SHUCK (NASA, Flight Research Center, Edwards, CA) AIAA, SFTE, DGLR, and SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990. 14 p. refs
(AIAA PAPER 90-1321) Copyright

Flight tests conducted with the self-repairing flight control system (SRFCS) installed on the NASA F-15 highly integrated digital electronic control aircraft are described. The development leading to the current SRFCS configuration is highlighted. Key objectives of the program are outlined: (1) to flight-evaluate a control reconfiguration strategy with three types of control surface failure; (2) to evaluate a cockpit display that will inform the pilot of the maneuvering capacity of the damaged aircraft; and (3) to flight-evaluate the onboard expert system maintenance diagnostics process using representative faults set to occur only under maneuvering conditions. Preliminary flight results addressing the operation of the overall system, as well as the individual technologies, are included. V.T.

A90-34820#
ROTARY DAMPING IN AIRCRAFT MOTION DUE TO JET PROPULSION SYSTEM
M. M. NITA (Institutul Politehnic, Bucharest, Rumania) and R. PATRAULEA (Civil Aviation Department, Bucharest, Rumania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 35, Jan.-Feb. 1990, p. 3-15.

An aircraft is taken as a variable mass system due to the continuous capture of air and ejection of combustion gas particles. By applying the equation of motion about the center of mass of such a system, the occurrence of a term acting as a supplementary damping moment due to the jet propulsion system is pointed out. This term is dependent on the location of the jet engine's inlet and exhaust, as well as on the position of the free surfaces of the liquid in the fuel tanks; it is generally a coupling term for the longitudinal and lateral motion. The relative importance of this gasdynamic damping moment is then evaluated against the aerodynamic damping derivatives for some current jet aircraft. S.A.V.

A90-34822#
ANALYSIS OF PERTURBED LONGITUDINAL DYNAMICS OF AN AIRCRAFT TAKING INTO CONSIDERATION THE STATIONARY AEROELASTIC EFFECTS AND THE ATMOSPHERIC PERTURBANCES
CARMEN ALEXE (Institutul Politehnic, Bucharest, Rumania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 35, Jan.-Feb. 1990, p. 33-38. refs

The effects of stationary aeroelastic vibration modes on the perturbed longitudinal dynamics of an aircraft is examined. The study is conducted through modeling, modal analysis, and real-time response to standard inputs. The degree of perturbation of the system is studied by introducing the effect of atmospheric turbulence. A case study is performed for an aircraft with dynamics strongly influenced by these effects. For delta-wing aircraft of sufficiently large dimensions, the effect of aeroelastic vibrations is comparable to that of longitudinal rigid modes. S.A.V.

N90-20092# Range Commanders Council, White Sands Missile Range, NM. Range Safety Group.
FLIGHT TERMINATION SYSTEM BATTERY GUIDELINES
Oct. 1989 20 p
(AD-A217310; RCC/RSG-318-89) Avail: NTIS HC A03/MF A01 CSCL 10/3

This document is intended to be used as a guide for range users requiring a flight termination battery. It will provide the user with guidelines for incorporating technical and safety criteria necessary to describe a power source (battery) which will be compatible with the mission critical needs of a flight termination system (FTS). All batteries used to provide the electrical power for an FTS shall have a proven performance reliability of .999 at the 95 percent confidence level. Performance reliability shall be established through statistically based testing. The battery specification, as a minimum, shall include all of the applicable operational, mechanical, electrical, and environmental characteristics of the FTS. As a final product, any battery to be used with an FTS shall be from those units for which lot-acceptance data is in compliance with the specification and the data evaluation requirements of this document. A quality assurance program, such as MIL-Q-9858, must be invoked in the purchase document and placed in operation concurrent with the qualification program so as to allow its assessment prior to beginning production. GRA

N90-20093*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DIGITAL-FLUTTER-SUPPRESSION-SYSTEM INVESTIGATIONS FOR THE ACTIVE FLEXIBLE WING WIND-TUNNEL MODEL
BOYD PERRY, III, VIVEK MUKHOPADHYAY, SHERWOOD T. HOADLEY, STANLEY R. COLE, CAREY S. BUTTRILL, and JACOB A. HOUCK Mar. 1990 13 p Presented at the AIAA 31st Structures, Structural Dynamics, and Materials Conference, Long Beach, CA, 2-4 Apr. 1990
(NASA-TM-102618; NAS 1.15:102618) Avail: NTIS HC A03/MF A01 CSCL 01/3

Active flutter suppression control laws were designed, implemented, and tested on an aeroelastically-scaled wind tunnel model in the NASA Langley Transonic Dynamics Tunnel. One of the control laws was successful in stabilizing the model while the dynamic pressure was increased to 24 percent greater than the measured open-loop flutter boundary. Other accomplishments included the design, implementation, and successful operation of a one-of-a-kind digital controller, the design and use of two simulation methods to support the project, and the development and successful use of a methodology for on-line controller performance evaluation. Author

N90-20094# Wright Research Development Center, Wright-Patterson AFB, OH. Flight Dynamics Lab.
LABORATORY IMPLEMENTATION OF THE CONTINUOUSLY RECONFIGURING MULTI-MICROPROCESSOR FLIGHT CONTROL SYSTEM (CRMMFCS) Final Report, Apr. 1980 - Jun. 1984
BILL ROLLISON, DAN THOMPSON, RAY BORTNER, STAN PRUETT, and MARK MEARS Oct. 1989 98 p
(AD-A217730; WRDC-TR-89-3114) Avail: NTIS HC A05/MF A01 CSCL 01/4

The initial CRMMFSC report highlighted the theoretical concepts and established the boundaries for realizing an autonomously distributed control system. The hardware and software methods used in the laboratory model to achieve the goals as set down in the concept phase are discussed. The discussion highlights the hardware construction, revealing the operations and the reasoning behind the choices made. The section on software reviews the techniques used to glue the hardware together to become a system. The completed laboratory model and its testing under a number of conditions are discussed. GRA

N90-20095# Human Engineering Labs., Aberdeen Proving Ground, MD.
INTERACTION OF SWITCH ACTUATION ON TRACKING WITH A FOUR-AXIS FLIGHT CONTROL (CROSS-COUPLING) Final Report
WILLIAM B. DEBELLIS Dec. 1989 49 p
(Contract DA PROJ. 1L1-62716-AH-70)
(AD-A217981; HEL-TM-17-89) Avail: NTIS HC A03/MF A01 CSCL 01/4

This is the third in a series of investigations to generate a data base for multiaxis side arm flight controls. The purpose of this research is to determine the interaction between switch actuation and tracking performance while tracking in four axes.

The research is required to specify the number and locations of switches that can be placed on the flight control. The long range goal is to provide design recommendations and input to military specifications and standards. Tracking errors increase when switches associated with this control grip and controller mechanism are operated. GRA

N90-20936*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
APPLICATION OF STOCHASTIC ROBUSTNESS TO AIRCRAFT CONTROL SYSTEMS
LAURA E. RYAN *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 145-166 Mar. 1990
Avail: NTIS HC A10/MF A02 CSCL 01/3

Guaranteeing robustness has long been an important design objective of control system analysis. Stochastic robustness is a simple numerical procedure that can be used to measure and gain insight into robustness properties associated with linear control systems. In the realm of aircraft control systems, problems such as the effects of flight condition perturbations and model-order uncertainties on robustness are easily and effectively analyzed using stochastic robustness. The concept of stochastic robustness is reviewed and examples are presented demonstrating its use in flight control system analysis. Author

N90-20937*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
NEURAL NETWORKS FOR AIRCRAFT CONTROL
DENNIS LINSE *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 167-181 Mar. 1990
Avail: NTIS HC A10/MF A02 CSCL 01/3

Current research in Artificial Neural Networks indicates that networks offer some potential advantages in adaptation and fault tolerance. This research is directed at determining the possible applicability of neural networks to aircraft control. The first application will be to aircraft trim. Neural network node characteristics, network topology and operation, neural network learning and example histories using neighboring optimal control with a neural net are discussed. Author

N90-20939*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
RULE-BASED MECHANISMS OF LEARNING FOR INTELLIGENT ADAPTIVE FLIGHT CONTROL
DAVID A. HANDELMAN and ROBERT F. STENGEL *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 189-194 Mar. 1990
(Contract DAAG29-84-K-0048)
Avail: NTIS HC A10/MF A02 CSCL 01/3

How certain aspects of human learning can be used to characterize learning in intelligent adaptive control systems is investigated. Reflexive and declarative memory and learning are described. It is shown that model-based systems-theoretic adaptive control methods exhibit attributes of reflexive learning, whereas the problem-solving capabilities of knowledge-based systems of artificial intelligence are naturally suited for implementing declarative learning. Issues related to learning in knowledge-based control systems are addressed, with particular attention given to rule-based systems. A mechanism for real-time rule-based knowledge acquisition is suggested, and utilization of this mechanism within the context of failure diagnosis for fault-tolerant flight control is demonstrated. Author

N90-20940*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
PERSPECTIVES ON THE USE OF RULE-BASED CONTROL
DAVID A. HANDELMAN and ROBERT F. STENGEL *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 195-200 Mar. 1990
(Contract DAAG29-84-K-0048)
Avail: NTIS HC A10/MF A02 CSCL 01/3

Issues regarding the application of artificial intelligence techniques to real-time control are discussed. Advantages associated with knowledge-based programming are discussed. A proposed rule-based control technique is summarized and applied to the problem of automated aircraft emergency procedure execution. Although emergency procedures are by definition predominately procedural, their numerous evaluation and decision points make a declarative representation of the knowledge they encode highly attractive, resulting in an organized and easily maintained software hierarchy. Simulation results demonstrate that real-time performance can be obtained using a microprocessor-based controller. It is concluded that a rule-based control system design approach may prove more useful than conventional methods under certain circumstances, and that declarative rules with embedded procedural code provide a sound basis for the construction of complex, yet economical, control systems. Author

N90-20941*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
STOCHASTIC ROBUSTNESS OF LINEAR CONTROL SYSTEMS
ROBERT F. STENGEL and LAURA E. RYAN *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1988-1989 p 201-206 Mar. 1990
(Contract NGL-31-001-252)
Avail: NTIS HC A10/MF A02 CSCL 01/3

A simple numerical procedure for estimating the stochastic robustness of a linear, time-invariant system is described. Monte Carlo evaluation of the system's eigenvalues allows the probability of instability and the related stochastic root locus to be estimated. This definition of robustness is an alternative to existing deterministic definitions that address both structured and unstructured parameter variations directly. This analysis approach treats not only Gaussian parameter uncertainties but non-Gaussian cases, including uncertain-but-bounded variations. Trivial extensions of the procedure admit alternate discriminants to be considered. Thus, the probabilities that stipulated degrees of instability will be exceeded or that closed-loop roots will leave desirable regions also can be estimated. Results are particularly amenable to graphical presentation. Author

N90-21039 Virginia Polytechnic Inst. and State Univ., Blacksburg.
EXPERIMENTAL AND THEORETICAL INVESTIGATION OF OPTIMAL CONTROL METHODS WITH MODEL REDUCTION
Ph.D. Thesis
GEORGE CUSHEN SCHAMEL, II 1989 140 p
Avail: Univ. Microfilms Order No. DA9003608

Three types of optimized controllers are developed and tested on two laboratory structures. The two structures represented a progression in complexity and challenge to the controllers. The first structure was simple enough to be accurately modeled so the analytical frequencies and mode shapes agreed with the experimental measurements. The second structure, being more complex, was more difficult to model so differences between the analytical results and experiment measurements were present. These differences required the application of a correction method to the reduced models developed for the second structure. The correction method was shown to work with good results on one reduced model and with poor results on the second reduced model. Two direct rate feedback control laws and a linear quadratic regulator with state estimation (LQG controller) were designed and implemented on both structures. It was shown that the performance of the LQG controller can be approached with a much simpler direct rate feedback controller with better analytical-experimental agreement. The best analytical-experimental agreement occurred with the simplest controller applied analytically to the corrected reduced model, demonstrating the validity of the correction method as well as giving a strong reason to use simpler controller designs. Dissert. Abstr.

N90-21040 Georgia Inst. of Tech., Atlanta.
DESIGN OF A HELICOPTER AUTOMATIC FLIGHT CONTROL SYSTEM USING ADAPTIVE CONTROL Ph.D. Thesis
PHILIP MATTHEW FITZSIMONS 1989 198 p
Avail: Univ. Microfilms Order No. DA9005476

Due to the complexity of the equations of motion governing the dynamics of the helicopter, the design of automatic flight control systems has proven to be a difficult, time consuming task, often employing ad hoc methods to reach a solution. There is a need for a systematic control system design procedure. Since handling quality specifications are often given in terms easily interpreted for linear time invariant system design, it is convenient to construct a reference model that exhibits satisfactory performance and design the control system such that the actual helicopter behaves like this reference model. One method of control system design that follows this approach is known as adaptive model following control. There is an established theory for the stability of adaptive model following control systems. However, this theory has the restriction that the helicopter (plant) dynamics are linear time invariant. The effects of considering nonlinearities (due to kinematics and aerodynamics) and unmodeled high frequency dynamics (due to the rotor dynamics) are considered. Two different mathematical models of the helicopter are used. One model calculates the aerodynamic forces and moments as functions of the control positions and vehicle velocities and uses Euler's equations. The other model uses the same structure except that it includes a transfer function approximation to the rotor dynamics at the inputs to assess the impact of unmodeled high frequency rotor dynamics on the performance of the control system. The helicopter models are based on the McDonnell Douglas Helicopter Company's Apache AH-64. Author

N90-21041# Helsinki Univ. of Technology, Espoo (Finland). Lab. of Aerodynamics.
SUBSONIC FLUTTER ANALYSIS USING MSC/NASTRAN
KARI RENKO 10 Jul. 1989 158 p Sponsored by Finnish Air Force
(PB90-166786; SER-B-89-B16; ISBN-951-754-951-2) Avail: NTIS HC A08/MF A01 CSCL 01/1

Standard practices to perform flutter analyses on complex aircraft configurations in subsonic flow are presented. Flutter solution is performed using the MSC/NASTRAN program. Modifications to MSC/NASTRAN's flutter solution are devised to allow the calculation of unsteady pressure distribution on lifting surfaces and the use of ground vibration test results to represent the dynamic properties of the structure. Several supplementary programs are included which transfer model geometry and analysis results into the SDRC I-DEAS program package's database. The I-DEAS package is then used to visualize the data. Several output routines were written to generate two dimensional xy-plots of analysis results. Author

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RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A90-32463*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
TURBULENCE MEASUREMENTS AND NOISE GENERATION IN A TRANSONIC CRYOGENIC WIND TUNNEL
W. F. NG, M. GUNDAPPA, D. O. GRIFFITH, II (Virginia Polytechnic Institute and State University, Blacksburg), and J. B. PETERSON, JR. (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 28, May 1990, p. 853-858. refs
(AIAA PAPER 88-2026) Copyright

A high-frequency combination probe was used to measure dynamic flow quality in the test section of the NASA Langley 0.3-m Transonic Cryogenic Tunnel. The probe measures fluctuating stagnation (total) temperature and pressure, static pressure, and flow angles in two orthogonal planes. Simultaneous measurements of unsteady total temperature and pressure were also made in the settling chamber of the tunnel. The data show that the stagnation temperature fluctuations remain constant, and the stagnation pressure fluctuations increase by a factor of two, as the flow accelerates from the settling chamber to the test section. In the test section, the maximum rms value of the normalized fluctuating velocity is 0.7 percent. Correlation coefficients failed to show vorticity, entropy, or sound as the dominant mode of turbulence in the tunnel. Author

A90-33370#
MEASUREMENT OF WIND TUNNEL MODEL DEFORMATION UNDER AIRLOAD
H. HOENLINGER, R. MANSER (MBB GmbH, Munich, Federal Republic of Germany), A. GRAVELLE, and P. VIGUIER (ONERA, Chatillon-sous-Bagneux, France) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 205-211.

A simple opto-electronic method is presented which is able to measure the displacement of a set of target points integrated into the model surface. The target points are projected on a CCD array. A displacement of the target points on the model causes a travel of the target point image on the CCD array. This effect together with appropriate calibration is usable for touchless deformation measurements. The method was experimented during two test series on different models and the test results are presented. The interpretation of the measurement methods and test results as far as the important induced twist angle distribution is concerned led to a previous smoothing of the displacement measurements. Two different smoothing methods are presented and compared with the results. Author

A90-33371#
GROUND VIBRATION TESTING OF AEROPLANES WITH A SEQUENCE OF SINGLE-POINT EXCITATIONS - SIMPLE AND EFFECTIVE
P. SCHIPPERS (Fokker Aerodynamics and Aeroelasticity, Schiphol, Netherlands) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 213-222. refs

Single-point excitations on a number of previously selected locations on the structure are used in order to avoid shortcomings inherent in simultaneous multipoint excitation. For each single-point excitation a reduced number of vibration modes is measured with sine excitation in combination with the measurement of frequency response functions measured with random excitation. This sequence of single-point excitations is employed in the ground vibration test (GVT) of two aircraft. The phase-separation method in a semiautomated postprocess is used to identify closely-spaced, almost identical vibration modes in the frequency response functions. Comparison of the GVT results with those of the analytical model reveals that no modes are missed for both aircraft in the given frequency range, while the test time is reduced. V.T.

A90-33910#
UH-60 HELICOPTER SIMULATOR FIDELITY TESTING OR HOW TO MAKE IT FLY LIKE THE REAL THING
DAVID A. DOWNEY (U.S. Army, Aviation Engineering Flight Activity, Edwards AFB, CA) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 248-257. refs
(AIAA PAPER 90-1290) Copyright

An account is given of the consideration of the test pilot as an integral part of the fidelity evaluation of simulators, with reference to fidelity-enhancement efforts involving the NASA-Ames Vertical

Motion Simulator/UH-60A GEN HEL model and the U.S. Army's UH-60A Flight Simulator. Specific examples are presented of simulator shortcomings discovered by test pilots in the course of simulator fidelity assessments, concerning roll-damping, rearward flight, engine/rotor response, yaw inputs, flight path stabilization, etc. The importance of multidisciplinary approaches to the problems encountered is highlighted. O.C.

A90-33919#
GROUND TESTING TECHNIQUES IN SUPPORT OF FLIGHT TEST
STEVEN C. DUNN (Sverdrup Technology, Inc., Arnold AFB, TN) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 329-336. refs
(AIAA PAPER 90-1309)

An account is given of techniques used to conduct simulated altitude fighter aircraft engine tests at a USAF ground testing facility. While certain effects that may be studied in flight tests are not exactly duplicated in ground testing, it is shown that data-gathering capabilities encompassing on-line data analysis at low relative cost render ground testing extremely useful; hardware and software optimization prior to flight testing can be conducted with great efficiency and effectiveness. Attention is given to engine steady-state and transient operations, afterburner operation, inlet distortion, and ice-accretion testing. O.C.

A90-34226#
PETW TESTING RESULTS
JEAN PIERRE HANCY and JEAN MUYLAERT (European Transonic Windtunnel GmbH, Cologne, Federal Republic of Germany) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 34 p.

The Pilot European Transonic Wind Tunnel (PETW) is discussed. A general description and historical background of the PETW is given, including early rotation and commissioning and test campaigns. Results are described of PETW flow quality tests, circuit loss tests, second throat tests, double roll tests, noise measurement tests, and supersonic tests. Future utilization of the PETW is addressed. C.D.

A90-34228#
CRYOGENIC WIND TUNNELS IN JAPAN
ROBERT A. KILGORE European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 4 p. refs

The cryogenic wind tunnel activities in Japan are briefly reviewed. The emphasis is on the mechanical, aerodynamic, and operational aspects of the four cryogenic tunnels in Japan. Two new transonic cryogenic tunnels have been proposed to meet the high Reynolds number testing needs in Japan. The first would have a 0.6 x 0.6 m test section and serve as a pilot tunnel for a much larger tunnel. The larger tunnel would have a 3 x 3 m test section. It would operate at Mach numbers from 0.2 to 1.2 at pressures up to 9 bars. Author

A90-34230#
THE KRYO-KANAL KOELN, KKK: DESCRIPTION OF TUNNEL CONVERSION - RESULTS OF CALIBRATION TESTS UNDER AMBIENT AND CRYOGENIC CONDITIONS
G. VIEHWEGER (DLR, Cologne, Federal Republic of Germany) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 17 p. refs

The modified Kryo-Kanal at Koeln (KKK) is described, including the test section, fan and drive system, liquid nitrogen system, exhaust and blow-in system, and internal insulation. Modeling and control of the tunnel is analytically discussed, and the aerodynamic and cryogenic calibration of the tunnel are reviewed. The temperature of the test gas in the modified tunnel can be varied with a range of 300 and 100 K. The maximum Reynolds number achieved at the lower temperature is 8.9 x 10 to the 6th. Even at the lowest tunnel temperature, the deviation of the temperature in the test section is better than + or - 0.5 K. C.D.

A90-34232#
INVESTIGATION OF MODEL RIGGING LIMITATIONS ON A HIGH SPEED WIND TUNNEL MODEL AT CRYOGENIC TEMPERATURE
A. THOMASON (British Aerospace, PLC, Military Aircraft Div., Warton, England) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 9 p.

Model rigging experiments were carried out on a 1/20 scale military aircraft model in a cryogenic chamber. A model-rigging technique was developed in which configuration changes could be achieved with the rigger wearing unsophisticated protective clothing and using inexpensive tools and model aids. However, the tests showed that configuration changes would be much easier to accomplish if the cold model is rigged in a dry ambient atmosphere. C.D.

A90-34233#
A MEASUREMENT WINDOW FOR A CRYOGENIC WINDTUNNEL
H. G. KOENIG and B. EWALD (Darmstadt, Technische Hochschule, Federal Republic of Germany) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 8 p.

A medium-sized thermal isolating window for direct viewing into the measurement section of a cryogenic wind tunnel has been constructed. The basic principle of the window involves a two-pane structure with a high-vacuum isolation gap in between. The calculation of the thermal flux through the window and the window's optical performance, safety, and reliability are discussed. The design of the window is addressed, examining the cold seals, evacuation system, and heating techniques. Test results of the window are summarized which indicate that a window of this type would allow application of highly sophisticated measurement techniques like schlieren methods, interferometry, LDA, L2F, and optical triangulation which heretofore have mostly had to be used at room temperatures and away from wind tunnel measurement sections. C.D.

A90-34237#
BALANCE CALIBRATION AND EVALUATION SOFTWARE
B. EWALD (Darmstadt, Technische Hochschule, Federal Republic of Germany) and T. BALDEN (MBB GmbH, Bremen, Federal Republic of Germany) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 9 p.

A new procedure for evaluating the calibration matrix from calibration data and wind tunnel test loads from balance readings during wind tunnel tests is presented. A more or less arbitrary calibration matrix is used to simulate a calibration data set. Calibration data from a cryogenic balance is used to prove the reliability of the method. The advantages of the method, when compared to previous ones, are, among others: (1) the calibration matrix is evaluated as a closed solution of the whole data set, (2) specific load ranges can easily be extracted from the data set to get a matrix especially for these load ranges, and (3) the third-order formulation of the problem makes it possible to simulate symmetric balance character. C.D.

A90-34238#
DESIGN AND MANUFACTURE OF A CRYOGENIC WIND TUNNEL MODEL
UWE GROSS (MBB GmbH, Munich, Federal Republic of Germany) and HELMUT LUECK (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 20 p. refs

The design of the TST cryogenic wind tunnel model is described. The choice of model scale; general model data; simulation of the

flight envelope; and model and balance loads, tolerances, and surface requirements are briefly presented. The design of the balance adapter, fuselage, wing, vertical tail, horizontal stabilizer, and attachment screws are examined, and a stress analysis of the TST model is summarized. The material of the model is briefly described, and the model instrumentation is outlined. Special problems encountered in the manufacture of the model are reviewed, including those pertaining to the steel material, manufacture pretests, surface quality, stepped specimens, wedge specimens, and three-dimensional specimens. The outlook for the project is briefly addressed. C.D.

A90-34240#
FLOW QUALITY IN THE T2 CRYOGENIC WIND-TUNNEL - PROBLEMS AND SOLUTIONS
A. BLANCHARD, J. B. DOR, A. SERAUDIE, and J. F. BREIL (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 22 p. refs

The T2 wind tunnel is transonic, pressurized, cryogenic, driven by induction, fitted with adaptive walls, and internally insulated. The milestones of this tunnel are reviewed, and its steady flow accuracy, flow unsteadiness, and fluid purity are discussed. Examples of problems encountered by the tunnel are briefly addressed. C.D.

A90-34241#
T2 ABILITY CONCERNING MODEL DESIGN AND INSTRUMENTATION IN SHORT RUN PROCESSING
A. MIGNOSI, J. P. ARCHAMBAUD, S. PRUDHOMME, M. PLAZANET, and M. J. PAYRY (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 14 p. refs

The transonic induction driven wind-tunnel T2 at ONERA has gained considerable experience in cryogenic testing since 1981. In parallel with the wind tunnel experience, progress has been made in model design and instrumentation. Following an initial period with bulky airfoils cooled near the test section before the run, low thermal inertia models have been developed. Their 3 mm thin skin allows cooling by the wind-tunnel flow at low speed in less than one minute. Various types of models that show the increase of complexity and development of technology, ranging from two-dimensional massive models to three-dimensional light models are described. Finally, T2 model instrumentation is examined relative to pressure and temperature measurement, optical fibers, and accelerometers and strain gauges in a cryogenic environment.Some experimental test results are provided. R.E.P.

A90-34242#
HALF TRANSPORT AIRCRAFT CRYOGENIC MODEL FOR T2 WIND TUNNEL
F. DUPRIEZ, P. GEOFFROY, and G. OUTTIER (ONERA, Institut de Mecanique des Fluides, Lille, France) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 10 p.

The design, construction, and instrumentation of a cryogenic model of a transport aircraft for buffeting tests in the T2 wind tunnel are examined. The model and its instrumentation are described, and the FEM and aerodynamic pressure-field modeling are discussed. The evaluation of the deflection and of the stresses of the model under buffeting loads of the the dynamic behavior of the clamped wing is addressed. The fuselage and wing-attachment design is described. C.D.

A90-34243#
A FEASIBILITY STUDY FOR A COMBAT AIRCRAFT MODEL STING FOR THE EUROPEAN TRANSONIC WIND TUNNEL
A. THOMASON (British Aerospace, PLC, Military Aircraft Div., Warton, England) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 23 p.

The conceptual sting design incorporates a flange joint at the downstream end and a cylindrical taper joint at the model end. The material chosen is DTD 5212, a high strength maraging steel. A structural analysis of the design has been carried out and recommendations are made regarding future low temperature toughness testing for the sting material. Based on the conceptual design, indicative costs are included for the detail design, structural analysis and manufacture. Author

A90-34245#
STING DESIGN FEASIBILITY FOR E.T.W. CRYOGENIC CIVIL TRANSPORT AIRCRAFT
F. DUPRIEZ, B. PALUCH, and J. L. PETITNIOT (ONERA, Institut de Mecanique des Fluides, Lille, France) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 17 p.

The feasibility of a straight rear sting with a circular cross section to be employed in a cryogenic wind tunnel for civil transport aircraft testing is studied. Design limitations are considered from the point of view of maximum stress as related to fatigue limit stresses, as well as minimum aerodynamic interaction between the model and the sting. Specifications and dimensions are discussed along with materials including metallic alloys and composite materials. Different types of joints are considered, and thermal stresses induced by rapid changes in temperature are covered. A family of stings with increasing degrees of aerodynamic interaction is proposed. V.T.

A90-34246#
A PROPOSED AUTOMATIC CALIBRATION FACILITY FOR CRYOGENIC BALANCES
R. PORTER (Aircraft Research Association, Ltd., Bedford, England) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 8 p.

This paper summarizes the results of a feasibility study of balance calibration methods undertaken for SC-ETW as part of the ETW Cryogenic Technology Programme. The proposed automatic calibration machine uses servo-controlled pneumatic load generators to apply any required combinations of load components. Two systems of jacks are used to maintain the attitude of the live end of the balance and to minimize travel of the load generators. A segmented cooler surrounds the balance for calibration at uniform cryogenic temperatures or with temperature gradients. Author

A90-34247#
AUTOMATIC CALIBRATION MACHINE FOR INTERNAL CRYOGENIC BALANCES
B. EWALD (Darmstadt, Technische Hochschule, Federal Republic of Germany), P. GIESECKE (Carl Schenck AG, Darmstadt, Federal Republic of Germany), E. GRAEWE, and T. BALDEN (MBB GmbH, Bremen, Federal Republic of Geramny) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 19 p.

A feasibility study to develop an automatic calibration rig for cryogenic balances is offered. Apart from automatic operation the rig must fulfill any requirements that result from the special technology of cryogenic balances and from the accuracy requirements. Relevant aspects of accuracy, repeatability and signal resolution, and the calibration structure of the rig are described. Controlling and safeguarding of the applied forces, the cryogenic cooling box, and the data acquisition system are also defined. Finally, some general aspects for the positioning and alignment of the internal balance to be calibrated are discussed. R.E.P.

A90-34248#
RESULTS OF STUDIES ON A MANIPULATOR SYSTEM FOR MODEL HANDLING IN THE ETW
K. LOTTER and R. LEISTNER European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 26 p.

An electric master-slave-manipulator system to be used for

model modifications and instrumentation check-out in the 'variable check-out room' is analyzed and its feasibility is demonstrated. The use of a manipulator is expected to represent the least harmful procedure for wind tunnel model modifications in the cold, life-hostile nitrogen atmosphere of the European Transonic Wind Tunnel (ETW). Unnecessary temperature cycles with the associated thermal stresses in both the model and wind tunnel structure can thus be avoided. In addition, higher tunnel productivity and a reduction in energy can be achieved. Future application in the ETW test section is also considered. R.E.P.

A90-34251#
DEVELOPMENT OF CRYOGENIC INSTRUMENTATION FOR ETW MODELS
R. G. SCURLOCK and R. WEBB (Southampton, University, England) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 11 p. refs

A prototype eight-channel (four pressure and four temperature) computer-controlled electronic signal conditioning data logging system capable of operating at temperatures between 77.5 K and 300 K with a precision of + or - 0.05 percent is described. To achieve + or - 0.02 percent requires circuit development as well as temperature correction of the digitized output signals using the temperature signals from the integral diode thermometers mounted on the system pressure sensors; the logger computer can be employed to carry out the latter operation on each pressure reading. The logger has 16-channel capability in its present form and since it is constructed in modular form, further 16 channel modules can be added. V.T.

A90-34252#
MEASUREMENT OF TEMPERATURE GRADIENTS AND ASSESSMENT OF BALANCE PERFORMANCE USING THE RAE CRYOGENIC TEST DUCT
R. D. LAW (Royal Aerospace Establishment, Bedford, England) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 30 p. refs

Temperature gradients affecting the outputs of strain gaged balances at cryogenic temperatures are studied. For each experiment, an external body of revolution is fitted over the balance to provide shielding from a gas flow. The magnitude and direction of the temperature gradients is evaluated while the flow is cooled from ambient to 90 K. The effect of eliminating convection currents within and around the balance using a polystyrene infill is assessed. It is demonstrated that thermally induced force excursions in the gage linked balance during the thermal transients can be established from the measured temperature data as well as by direct force measurements. An axial force calibration carried out at ambient and cryogenic temperatures is analyzed to assess sensitivity changes, along with pitch and normal force interactively to assess any changes in the magnitude of these interactions at low temperatures. V.T.

A90-34578
RAIN EROSION TESTING
WILLIAM F. ADLER (General Research Corp., Santa Barbara, CA) IN: Window and dome technologies and materials; Proceedings of the Meeting, Orlando, FL, Mar. 27-29, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 275-294. refs
Copyright

The water drop impact conditions prevailing in several rotating arm facilities are analyzed. Indirect measurements of the water drop impacts on polymethylmethacrylate specimens were made when each facility was operating in order to evaluate the effects of the aerodynamic interactions on the actual water drop impact conditions in each facility. These results are contrasted with the static measurements of the water drop dimensions in order to demonstrate the consistency between the static evalutions and the dynamic operating conditions unique to each facility. It is found that the stated monodispersed distribution of 2.0 mm spherical water drops in these facilities is actually deviating significantly from this idealized condition when they collide with the specimen. Author

A90-34580
MULTIPLE IMPACT JET APPARATUS (MIJA) - APPLICATION TO RAIN EROSION STUDIES
P. N. H. DAVIES and J. E. FIELD (Cambridge, University, England) IN: Window and dome technologies and materials; Proceedings of the Meeting, Orlando, FL, Mar. 27-29, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 316-327. Research supported by the Ministry of Defence Procurement Executive. refs
Copyright

A multiple jet impact apparatus (MIJA) which allows multiple impact to be studied in a controlled way has been developed. Using the same nozzle design as previous single-impact devices, MIJA produces jets by pneumatically acclerating a titanium shaft into the rear water chamber of the nozzle. The shock-accelerated jets are of the high quality necessary for simulating 2-10-mm diameter drop impact. Impact velocities in the range up to about 250 m/s have been achieved. The velocity and position of impact of each jet can be controlled, and repetition rates of about 10/min can be maintained for extended periods of time. This paper describes the design, construction, and performance of MIJA, and presents experimental data on threshold velocities and damage development. C.D.

A90-34585
DESIGN CONSIDERATIONS FOR A COMPACT TABLE TOP HYPERSONIC SIMULATOR OF AERO-OPTIC EFFECTS
RODNEY L. CLARK, D. A. KALIN, S. C. CHAN, and S. M. LAWSON (Teledyne Brown Engineering, Huntsville, AL) IN: Window and dome technologies and materials; Proceedings of the Meeting, Orlando, FL, Mar. 27-29, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 368-376. refs
Copyright

The flight aerooptic environment is examined and the mixing layer is determined to be the largest aerooptic contributor. The way in which this mixing layer can be reproduced in a ground test facility is examined. A compact hypersonic aerooptic simulator which properly scales the mixing layer is described. This small simulator is designed to emulate the significant aerooptic features of the hypersonic window coolant mixing layer present in current interceptor designs. Author

A90-34586
TABLE TOP EXPERIMENTAL SIMULATION OF HYPERSONIC AERO-OPTICAL EFFECTS
D. A. KALIN and R. L. CLARK (Teledyne Brown Engineering, Optical Systems Dept., Huntsville, AL) IN: Window and dome technologies and materials; Proceedings of the Meeting, Orlando, FL, Mar. 27-29, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 377-381.
(Contract DASG60-87-C-0042)
Copyright

Renewed interest in hypersonic interceptors has generated a requirement to validate optical sensor performance in the hypersonic environment. This paper presents a novel experimental test setup that emulates the most significant aerooptic effect, namely the mixing/shear layer produced by the supersonic gas used as a coolant for the window in such optical seeker interceptors. Boresight error, image blurring, transmission loss, and jitter are experimentally measured and compared to theoretical predictions for the same test conditions. A Q-switched Nd:YAG laser provides the source illumination. Image information is gathered with a high-speed video data system operating with an angular resolution of about one microradian. Proof-of-principle tests to demonstrate the feasibility of the concept and to generate an initial set of data are described. C.D.

N90-20096* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AIRPLANE TAKEOFF AND LANDING PERFORMANCE MONITORING SYSTEM Patent
DAVID B. MIDDLETON, inventor (to NASA), RAGHAVACHARI SRIVATSAN, inventor (to NASA), and LEE H. PERSON, inventor (to NASA) 27 Jun. 1989 25 p Filed 6 Aug. 1987 Prepared in cooperation with Kansas Univ., Lawrence
(NASA-CASE-LAR-13734-1-CU; US-PATENT-4,843,554; US-PATENT-APPL-SN-082766; US-PATENT-CLASS-364-427; US-PATENT-CLASS-73-178-T) Avail: US Patent and Trademark Office CSCL 14/2

The invention is a real-time takeoff and landing performance monitoring system which provides the pilot with graphic and metric information to assist in decisions related to achieving rotation speed (V sub R) within the safe zone of the runway or stopping the aircraft on the runway after landing or take off abort. The system processes information in two segments: a pretakeoff segment and a real-time segment. One-time inputs of ambient conditions and airplane configuration information are used in the pretakeoff segment to generate scheduled performance data. The real-time segment uses the scheduled performance data, runway length data and transducer measured parameters to monitor the performance of the airplane throughout the takeoff roll. An important feature of this segment is that it updates the estimated runway rolling friction coefficient. Airplane performance predictions also reflect changes in headwind occurring as the takeoff roll progresses. The system displays the position of the airplane on the runway, indicating runway used and runway available, summarizes the critical information into a situation advisory flag, flags engine failures and off-nominal acceleration performance, and indicates where on the runway particular events such as decision speed (V sub 1), rotation speed (V sub R) and expected stop points will occur based on actual or predicted performance. The display also indicates airspeed, wind vector, engine pressure ratios, second segment climb speed, and balanced field length (BFL). The system detects performance deficiencies by comparing the airplane's present performance with a predicted nominal performance based upon the given conditions.

Official Gazette of the U.S. Patent and Trademark Office

N90-20097# Army Cold Regions Research and Engineering Lab., Hanover, NH.
AIRFIELDS ON ANTARCTIC GLACIER ICE
MALCOLM MELLOR and CHARLES SWITHINBANK Dec. 1989 106 p
(Contract NSF DPP-87-001)
(AD-A217638; CRREL-89-21) Avail: NTIS HC A06/MF A01 CSCL 01/5

The physical characteristics of blue ice ablation areas in Antarctica are described and some representative ablation rates are given. The possibilities for using blue-ice areas as airfields are outlined and exploratory surveys are mentioned. Site details are given for icefields at Mount Howe, Mill Glacier, Patriot Hills, Rosser Ridge, Mount Lechner, S1 near Casey station, and on the Ross Ice Shelf near McMurdo station. The surface roughness of blue ice is discussed, microrelief surveys are presented for Mount Howe and Patriot Hills, and spectral analyses are used to develop relations between bump height and wavelength. U.S. military specifications for the roughness limits of various types of runways are summarized and graphical comparisons are made with the roughness analyses for Mount Howe and Patriot Hills. Special machines for smoothing ice runways are discussed and design specifications are developed. Some notes on ground facilities and ground transport are included. Appendices give discussions of weather patterns in the Transantarctic Mountains and methodology for making spectral analyses of surface roughness. It is concluded that glacier-ice airfields for conventional transport aircraft can be developed at low cost in Antarctica. Recommendations for further work are offered. GRA

N90-20098# Aeronautical Research Labs., Melbourne (Australia).
A DATA ACQUISITION PARALLEL BUS FOR WIND TUNNELS AT ARL (AERONAUTICAL RESEARCH LABORATORY)
J. F. HARVEY Aug. 1989 34 p
(AD-A218052; ARL-FLIGHT-MECH-TM-412; DODA-AR-005-629) Avail: NTIS HC A03/MF A01 CSCL 05/2

The data acquisition system used by the Subsonic Wind Tunnel at Aeronautical Research Laboratory, Melbourne, was designed in 1972. Tunnel productivity was further improved during 1982 with the installation of a dedicated computer (PDP11/44) which eliminated the time sharing access with the site's central computer. The dedicated computer also provides real-time processing of data and supports graphical displays for interactive operation with wind tunnel tests. In recent years this dedication minicomputer has become unreliable and the high cost of maintenance has led to its replacement with a micro VAX which is intended to be connected to similiar data gathering equipment to that used in the Subsonic Wind Tunnel. A data bus was developed to provide bi-directional communication between the dedicated master mini computer and the numerous microprocessor slave modules which form the new system. GRA

N90-20099# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
DESIGN OF A HIGH ANGLE OF ATTACK ROBOTIC STING MOUNT FOR TESTS IN A LOW SPEED WIND TUNNEL M.S. Thesis
TOMMY JACK KUBLER 1989 152 p
(AD-A218105; AFIT/CI/CIA-89-104) Avail: NTIS HC A08/MF A01 CSCL 14/2

A sting mounting system designed for high angle of attack (AOA) testing has been developed for the 7x10 foot low-speed wind tunnel (LSWT). The mechanism was able to position the model from -15 deg to +90 deg of pitch with accuracy to within 0.2 deg, while keeping the model near the center of the test section. Compatible with the current turntable apparatus, the high angle of attack robotic sting (HARS) retained the turntable's full range of yaw movement of + or - 90 deg. All model positioning was done without shutting the tunnel down to manually alter the sting or mounting apparatus. Pitch adjustment progressed at about 4 deg per second, with final position tuning taking nearly 15 seconds. The mechanism consisted of two square steel telescoping tube struts that were joined at the ends in the test section by a cross link that held the existing LSWT small Langley sting. Wind tunnel blockage and flow irregularities near the model were minimized by mounting drive hardware under the tunnel floor. An IBM/AT compatible microcomputer equipped with an analog-to-digital conversion board provided position control, drive motor signaling, and input signal filtering. GRA

N90-20100# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
RUNAWAY RUBBER REMOVAL M.S. Thesis
DEAN W. SIMPSON 1989 112 p
(AD-A218349; AFIT/CI/CIA-89-186) Avail: NTIS HC A06/MF A01 CSCL 01/5

When the wheels of landing aircraft impact a runway pavement, they deposit rubber on the pavement surface. As deposited rubber accumulates, the available friction between aircraft tires and the runway surface is reduced. This results in hazardous aircraft operating conditions. Factors affecting the need, method, and timing of rubber removal are addressed. GRA

N90-21042# Federal Aviation Administration, Atlantic City, NJ.
MODIFIED TOUCHDOWN ZONE LIGHTING
PAUL H. JONES Jan. 1990 15 p
(DOT/FAA/CT-TN89/70) Avail: NTIS HC A03/MF A01

A simulator evaluation was conducted to determine the adequacy of the standard touchdown zone (TDZ) lighting system under extremely low visibility conditions and to develop, if necessary, a modified TDZ lighting system. All testing was conducted using the Federal Aviation Administration (FAA) B-727

simulator at the Mike Monroney Aeronautical Center, Oklahoma City. The adequacy of the lighting system guidance was determined through pilot comments and by noting the aircraft track during the rollout. A post-flight questionnaire was completed by the test pilots. Only 10 out of 14 (71 percent) pilots were able to determine their location relative to centerline at 300 feet Runway Visual Range (RVR) with the standard TDZ lighting system. Some of the pilots could only determine their location down to 500 feet RVR, so a modified system was developed. With the modified system all pilots were able to achieve adequate centerline orientation at 300 feet RVR. From the results of this simulator evaluation we must conclude that, given a true reduced visibility condition of 300 to 500 feet RVR and with an automatic landing (auto-land) system malfunction which delivered the aircraft to a touchdown point immediately over the TDZ lighting system, a pilot would not have sufficient lateral guidance to achieve adequate centerline orientation during rollout. Author

N90-21043# National Aeronautical Lab., Bangalore (India). Systems Engineering Div.
HUMAN CENTRIFUGE CONTROLLER
T. V. S. RAO, VIJAYALAXMI SHANKAR, and C. ASWATH Feb. 1989 24 p
(NAL-TM-SE-8901) Avail: NTIS HC A03/MF A01

The aging electronic control desk for the Human Centrifuge System (HCS) at the Institute of Aviation Medicine (IAM), Bangalore was upgraded and rebuilt. HCS existence at IAM, its work and use are outlined. The NAL designed, personal computer (PC) based electron control desk used with the HCS to control the rotational speed of the Human Centrifuge (HC) is described. The control desk is used for running the HC to produce various g(acceleration) patterns such as normal g profiles and combat g profiles which are generally experienced by pilots. The PC is used for speed reference signal generation, supervision of the sequence of operations to be carried out at the start of the centrifuge and continuous checking of the correct operation of the overall HCS. The NAL designed control desk functionally replaces the original control desk and all the safety features that existed earlier have been retained in the new controller. Use of PC has resulted in a flexible programming environment and use of the latest available solid state components employed in building the controller has resulted in a reliable system. Author

N90-21044# Materials Research Labs., Maribyrnong (Australia).
A CORROSION FATIGUE/STRESS CORROSION TESTING FACILITY AT MATERIALS RESEARCH LABORATORY
M. Z. SHAH KHAN, I. A. BURCH, and B. J. BAXTER 1989 28 p
(MRL-TN-568; AR-006-288) Avail: NTIS HC A03/MF A01

The mechanical testing facility at Materials Research Laboratory was employed for conducting corrosion fatigue and stress-corrosion cracking investigations. Attention is focussed on adapting two servo-hydraulic testing machines (MTS) for corrosion fatigue endurance tests on smooth specimens, and the development of an electro-mechanical testing rig for corrosion fatigue crack growth and stress-corrosion cracking tests on notched specimens. Emphasis is placed on specimen design and experimental techniques in conjunction with relatively inexpensive and simple command generation devices. The method of measuring crack growth is reported. Fracture mechanics relations for the determination of crack tip stress-intensity and critical material properties are described. Author

N90-21045# Federal Aviation Administration, Washington, DC. Advanced System Design Service.
CRITERIA FOR POLYMER CONCRETE ON AIRPORT PAVEMENTS Final Report
KRISH PANDALAI Jul. 1989 175 p
(Contract DTFA-01-86-Y-01015)
(DOT/FAA/DS-89/18; AD-A219168) Avail: NTIS HC A08/MF A01

The subject of polymer concrete (PC) has generated a lot of interest among researchers during the past decade. This is due to the many advantages that polymer concrete pavement offers compared to regular portland cement concrete. The advantages of polymer concrete, when compared to portland cement concrete include, quick curing and setting, reduced moisture sensitivity and permeability and improved mechanical properties resulting in reduced pavement thickness to support the same load. These advantages will lead to attractive life cycle cost benefits. Material properties and mix designs for PC with epoxy, methylmethacrylate (MMA) and polyester as the binder material were investigated and presented. Pavement thickness design charts, developed for various aircraft, quality control methods, construction procedures and cost analysis are also presented. It was shown that increased material cost of PC can be offset by the reduced thickness of pavement. In order to develop life cycle cost information, it is necessary to obtain field performance data of PC pavement, especially in the composite design mode. Author

N90-21046# European Office of Aerospace Research and Development, London (England).
PROCEEDINGS OF THE 13TH INTERNATIONAL CONGRESS ON INSTRUMENTATION IN AEROSPACE SIMULATION FACILITIES
FRED T. GILLIAM Sep. 1989 10 p Congress held in Goettingen, Federal Republic of Germany, 18-21 Sep. 1989
(EOARD-LR-89-069) Avail: NTIS HC A02/MF A01

The technical program of the 13th International Congress on Instrumentation in Aerospace Simulation Facilities (ICIASF) is summarized. Important developments in instrumentation application, instrumentation system enhancements, and new systems being developed are briefly described here. Specific instrumentation systems discussed include laser Doppler velocimetry (LDV), particle image velocimetry (PIV), laser induced fluorescence (LIF), liquid crystals, infrared (IR) imaging, and several other techniques. Author

N90-21047*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL AEROELASTICITY HISTORY, STATUS AND FUTURE IN BRIEF
RODNEY H. RICKETTS Apr. 1990 14 p Presented at the AIAA/ASME/ASCE/AHS/ASC 31st Structures, Structural Dynamics, and Materials Conference, Long Beach, CA, 2-4 Apr. 1990 Previously announced in IAA as A90-29598
(NASA-TM-102651; NAS 1.15:102651; AIAA-90-0978) Avail: NTIS HC A03/MF A01 CSCL 14/2

NASA conducts wind tunnel experiments to determine and understand the aeroelastic characteristics of new and advanced flight vehicles, including fixed-wing, rotary-wing and space-launch configurations. Review and assessments are made of the state-of-the-art in experimental aeroelasticity regarding available facilities, measurement techniques, and other means and devices useful in testing. In addition, some past experimental programs are described which assisted in the development of new technology, validated new analysis codes, or provided needed information for clearing flight envelopes of unwanted aeroelastic response. Finally, needs and requirements for advances and improvements in testing capabilities for future experimental research and development programs are described. Author

N90-21049# Systems Control Technology, Inc., Arlington, VA.
INDIANAPOLIS DOWNTOWN HELIPORT: OPERATIONS ANALYSIS AND MARKETING HISTORY Final Report
DEBORAH J. PEISEN and ROBERT B. NEWMAN Mar. 1990 91 p
(Contract DTFA01-87-C-00014)
(REPT-90RR-13; DOT/FAA/DS-89/32) Avail: NTIS HC A05/MF A01

In response to increasing helicopter demand, the FAA initiated the FAA/Industry National Prototype Heliport Demonstration and Development Program. Four cities were selected for the demonstration program. These were: New York, New Orleans, Los Angeles, and Indianapolis. In January 1985, the Indianapolis Downtown Heliport was the first of the demonstration heliports to

open. The operational characteristics are analyzed of the Indianapolis Downtown Heliport from its opening in 1985 through March 1989, and the marketing techniques used during the planning and development stages of the heliport as well as the continuing marketing effort used to retain and increase business are studied. An analysis of operations at the heliport is performed using data collected by the heliport operators. The parameters examined concentrate on the types of missions, the variations and trends in the number of operations, the geographic distribution of the helicopters that use the facility, and the types of services required by the helicopter operators using the heliport. Due to limitations in the amount and accuracy of data available, only generalized trends rather than detailed statistical conclusions could be developed. Author

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ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A90-33382#
ROTORDYNAMICS OF THE VULCAIN LH2 TURBOPUMP - COMPARISON BETWEEN TEST RESULTS AND NON-LINEAR DYNAMIC ANALYSIS
F. LASSOUDIERE and C. BRUNE (SEP, Vernon, France) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 317-323. Research supported by CNES and ESA. refs

Development tests are currently being performed at SEP VERNON on the LH2 Turbopump of the Vulcain cryogenic engine. In spite of the difficulties inherent to the cryogenic environment, rotor displacements, bearing reactions, and stator accelerations are measured and provide numerous experimental data for rotor dynamics investigation. Within this framework, numerical nonlinear transient simulations are performed at SEP using the finite element code SAMCEF. Comparisons between experimental results and nonlinear analysis in terms of spectral response are shown, with a particular emphasis on the nonlinearities induced by clearances between bearing outer races and bearing carriers. Author

N90-20103# Air Force Wright Research and Development Center, Wright-Patterson AFB, OH.
ETO (EARTH-TO-ORBIT): A TRAJECTORY PROGRAM FOR AEROSPACE VEHICLES Final Report, Jan. 1987 - Jul. 1988
JOHN L. LEINGANG, WAYNE A. DONALDSON, KENNETH A. WATSON, and LOUIS R. CARREIRO Jun. 1989 90 p (AD-A218157; WRDC-TR-89-2023) Avail: NTIS HC A05/MF A01 CSCL 01/3

This is a formulation report and user guide for a two degree-of-freedom flight trajectory computer program. The program, called ETO, runs on IBM/compatible XT/AT microcomputers. It is designed for very short run times, i.e., less than 1 to 3 minutes. Horizontal or low angle takeoff single-stage or two-stage vehicles can be studies. Ascent to earth orbit or constant speed cruise can be studied. Any combination of airbreathing or rocket propulsion may be used. Working from tabular data for propulsion performance, aerodynamics, and vehicle weight and fuel, the governing equations of motion are integrated forward in time to track velocity, altitude, range, flight path angle, and weight. GRA

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CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A90-31516
THE STATUS OF HIGH TEMPERATURE POLYMERS FOR COMPOSITES - LIKELY CANDIDATES
DANIEL A. SCOLA (United Technologies Research Center, East Hartford, CT) IN: International SAMPE Symposium and Exhibition, 34th, Reno, NV, May 8-11, 1989, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 246-258. refs
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A comparative study has been performed of the isothermally-aged composite mechanical and chemical performance properties of several polymeric resins which appear to be promising candidates for application at service temperatures in the 287-343 C range, with attention to the degree to which each candidate is able to resist thermooxidative degradation above 316 C, as well as to production costs. The thermoplastic polymers considered are Sixef-44, Avimid-N, m-PPQ, LARC-TPI, Skybond 701, and Eymyd L-30N and -20N; the thermosetting polymers are PMR-15, PMR-II-30 and -50, and Thermid 600. Sixef-44 and Avimid-N exhibit the greatest thermooxidative stability. O.C.

A90-31575
REPAIR ADHESIVES - DEVELOPMENT CRITERIA FOR FIELD LEVEL CONDITIONS
MICHAEL J. CICHON (Dexter Corp., Dexter Adhesives and Structural Materials Div., Pittsburg, CA) IN: International SAMPE Symposium and Exhibition, 34th, Reno, NV, May 8-11, 1989, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 1052-1066.
Copyright

Data are presented which characterize the EA 9394 aircraft structural repair adhesive system's performance relative to bond-line thickness, elevated long-term storage conditions, cure-temperature variations, cure schedules, surface preparation, and mix ratio. Attention is given to such trade-offs in adhesive formulation as high temperature performance vs toughness, low cure temperature vs freezer storage, mix ratio insensitivity vs performance degradation, and better moisture and environmental corrosion resistance vs cost. The recommended cure cycle for EA 9394 is 5-7 days at room temperature or 1 hr at 200 F. O.C.

A90-31617
LIGHTNING STRIKE PROTECTION CONCEPTS FOR COMPOSITE MATERIALS
T. E. TRIPLETT (ICI Composites, Inc., Tempe, AZ) IN: International SAMPE Symposium and Exhibition, 34th, Reno, NV, May 8-11, 1989, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 1656-1667.
Copyright

Lightning-strike protection concepts such as conductive interwoven wire materials, conductive meshes, aluminized glass mattes, nickel-coated graphite web, and metal foils, that are considered for use with composite materials, are discussed. Their protection ability, areal weight, and processing characteristics are compared. It is concluded that, because of the effects of paint on the laminate surface, many of the nonpainted/nonprotected laminates fare just as well as some of the painted/protected ones; therefore, when laminates are painted, protection is required. If protection ability is the only consideration in choosing a protection material, the metal mesh materials are primary candidates; when protection ability, weight, and processing are all of concern, the

interwoven conductive wire materials are the most practical choice. N.B.

A90-31618
FLUOROSILICONE SEALANTS FOR AIRCRAFT FUEL CONTAINMENT
MYRON T. MAXSON, MADHU BAILE, and SCOTT E. FUSON (Dow Corning Corp., Midland, MI) IN: International SAMPE Symposium and Exhibition, 34th, Reno, NV, May 8-11, 1989, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 1668-1680.
Copyright

The use, properties, and testing of fluorosilicone sealants developed for the aerospace industry are discussed, including noncuring groove-injection sealants in three consistency grades, one-part room-temperature-cure (RTV) fillet sealants, and two-part addition-curing sealants for deep-section or confined fay-surface applications. It is demonstrated that fluorosilicone sealants have excellent resistance to all grades of jet fuels, as well as excellent primed adhesion, and are easy and safe to apply. They are also resistant to vibration, moisture, and ozone, and have a wide serviceable temperature range of -57 to 260 C for most materials. N.B.

A90-31619
SILICONE SEALANTS AND ADHESIVES FOR AEROSPACE/DEFENSE APPLICATIONS
MADHU BAILE and SCOTT E. FUSON (Dow Corning Corp., Midland, MI) IN: International SAMPE Symposium and Exhibition, 34th, Reno, NV, May 8-11, 1989, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 1681-1692.
Copyright

The properties and use of silicone sealants and adhesives developed for the aerospace industry are reviewed. The sealants reviewed include fluorosilicone sealants resistant to fuel, oils, and solvents at the temperature extremes experienced by fuel-containment systems; sealants for munitions casings that protect seams from moisture and are the key to the staged launch of many munitions systems; and sealants used for missile and aircraft fairing that are highly resistant to weather. Particular attention is given to a silicone interlayer that bonds the substrates used in canopies and periscopes and eliminates the delamination problems caused by rapid temperature cycling. All products offer optical clarity; low volatility; and temperature, weather, and fuel resistance to meet the most demanding specifications. N.B.

A90-31646
HIGH PERFORMANCE THERMOPLASTIC COMPOSITES WITH POLY(ETHERKETONEKETONE) MATRIX
JAMES F. PRATTE, WILLIAM H. KRUEGER, and IKE Y. CHANG (Du Pont de Nemours and Co., Fibers Dept., Wilmington, DE) IN: International SAMPE Symposium and Exhibition, 34th, Reno, NV, May 8-11, 1989, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 2229-2242. refs
Copyright

A development status evaluation is presented for poly(etherketoneketone) (PEKK) thermoplastic matrices, in combination with reinforcing carbon fibers. Attention is given to the 'long discontinuous fiber' (LDF) thermoformable laminate sheets, in comparison with more conventional, continuous-fiber thermoplastic laminates. LDF carbon-reinforced PEKK promises to yield lower costs in composite design and manufacture, as is presently illustrated by mechanical property data that indicate the extent to which this material system's thermoformable laminates possess intrinsically great controlled fiber-draw formability. O.C.

A90-31882
THERMOPLASTIC COMPOSITES, PAST, PRESENT AND FUTURE
G. R. GRIFFITHS (Westland Helicopters, Ltd., Yeovil, England) IN: Materials and processing - Move into the 90's; Proceedings of the Tenth International European Chapter Conference of SAMPE, Birmingham, England, July 11-13, 1989. Amsterdam, Elsevier Science Publishers, 1989, p. 101-109.
Copyright

The current status of thermoplastic composites and the work that needs to be completed in order to establish large-scale production of thermoplastic composites are briefly reviewed. In particular, attention is given to the advantages and disadvantages of thermoplastic components, potential application areas, principal manufacturing processes, and prospects for cost-effective automated large volume production. The design aspects of thermoplastic composite components and joining techniques are also discussed. V.L.

A90-31902
AEROSPACE MATERIALS - TRENDS AND POTENTIAL
W. BUNK (DLR, Institut fuer Werkstoff-Forschung, Cologne, Federal Republic of Germany), P. ESSLINGER (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, Federal Republic of Germany), and H. KELLERER (MBB GmbH, Munich, Federal Republic of Germany) IN: Materials and processing - Move into the 90's; Proceedings of the Tenth International European Chapter Conference of SAMPE, Birmingham, England, July 11-13, 1989. Amsterdam, Elsevier Science Publishers, 1989, p. 327-341. refs
Copyright

The current status of materials used for airframes and engines is reviewed with reference to the goals and limitations and the philosophies and strategies employed in the pursuit of these goals. In particular, attention is given to the competition between metals and polymer materials; cost considerations in relation to the requirements of safety and performance; recent developments in aluminum-lithium alloys, rapid solidification technology, and metal matrix composites; and materials for jet engines. V.L.

A90-32952#
PREDICTION OF TURBULENT COMBUSTION FLOWFIELDS BEHIND A BACKWARD-FACING STEP
FANG H. TSAU and WARREN C. STRAHLE (Georgia Institute of Technology, Atlanta) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, May-June 1990, p. 227-236. Previously cited in issue 07, p. 976, Accession no. A88-22249. refs
(Contract AF-AFOSR-83-0356)
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A90-32953#
HIGHER-ORDER EFFECTS IN BOUNDARY-LAYER PREMIXED COMBUSTION
C. TREVINO, N. PETERS (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany), and W. STUETTGEN Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, May-June 1990, p. 237-242. Research supported by the Stiftung Volkswagenwerk and Alexander von Humboldt-Stiftung. refs
Copyright

Higher-order effects in the boundary-layer theory are included in the present analysis to evaluate the interaction of the expansion process from the premixed combustion of reacting gases with the potential flow. Two cases are considered: (1) the premixed combustion process, which takes place above the flat plate; and (2) the premixed flame, which is generated in the wake of the flat plate. In both cases, the strong expansion process, when interacting with the outer inviscid flow, produces relatively strong pressure gradients, modifying the aerodynamic structure of the flow.
Author

A90-33078
EVALUATION OF VARIOUS NON-ASBESTOS EPOXY ADHESIVES FOR AIRCRAFT REPAIR
JOSEPH A. BRESCIA, KAREN L. MEYLER, and ANTHONY T. DESMOND (U.S. Army, Armament Research, Development and Engineering Center, Picatinny Arsenal, NJ) IN: International SAMPE Technical Conference, 21st, Atlantic City, NJ, Sept. 25-28,

1989, Proceedings. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 7-20. refs
Copyright

The results of a two-phase laboratory study seeking to identify a suitable nonasbestos epoxy adhesive for intermediate and depot-level metal/metal aircraft repairs are reported. Phase I of the program included the evaluation of sixteen adhesives as possible candidates. Studies included lap shear, T-peel, and sag/flow testing on aluminum oxide (grit) blasted 2024T3 aluminum. On the basis of the results obtained in Phase I, four of the sixteen were selected for further evaluation in Phase II of the program. Phase II studies included lap shear testing at -67 F, 75 F, 140 F, and 180 F, stress durability testing, and lap shear testing of specimens exposed to hydraulic fluids. DSC studies were also performed on each of the four adhesives to determine the effects of exposure to elevated temperature/humidity environments on glass transition temperatures. Author

A90-33098
HIGH SERVICE TEMPERATURE HIGH COMPRESSIVE STRENGTH AND TOUGH PREPREG SYSTEM
MAUREEN BOYLE and FRANK LEE (Hexcel Corp., Dublin, CA) IN: International SAMPE Technical Conference, 21st, Atlantic City, NJ, Sept. 25-28, 1989, Proceedings. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 294-303.
Copyright

A modified cyanate matrix resin system, HX-1562, exhibits very good retention of properties above 250 F after moisture saturation; in addition, high compressive strength and modulus are maintained throughout the service temperature range. The system can be processed at 350 F for two hours, without postcure, to obtain most of its optimum properties. By comparison to other prepreg systems, HX-1562 is rendered safer to work with by the exclusion of aromatic amines and other toxic ingredients from its composition. It has also been found to furnish more acceptable tack and drape characteristics. O.C.

A90-33126
DESIGNING AEROSPACE STRUCTURES WITH DU PONT'S LDF THERMOPLASTIC COMPOSITES
ANDY P. PERRELLA (Du Pont de Nemours and Co., Composites Div., Wilmington, DE) IN: International SAMPE Technical Conference, 21st, Atlantic City, NJ, Sept. 25-28, 1989, Proceedings. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 705-719. refs
Copyright

The aerospace composite structure system designated 'LDF' integrates advanced fiber-reinforced thermoplastic resins with state-of-the-art structural design practices and manufacturing capabilities to minimize the costs associated with conversion from one structural product to another. A multidisciplinary design effort is entailed by the automated LDF thermoforming process which ultimately controls material placement. Complex airframe structure demonstration articles have been thermoformed, and component mechanical properties tests have been undertaken to verify structural performance. O.C.

A90-33127
EROSIVE WEAR OF FIBROUS PEEK COMPOSITES
C. LHYMN and Y. O. LHYMN (YOON Technology, Erie, PA) IN: International SAMPE Technical Conference, 21st, Atlantic City, NJ, Sept. 25-28, 1989, Proceedings. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 720-729.
Copyright

An investigation is conducted of the erosive wear behavior of fiber-reinforced PEEK-matrix composites as a function of fiber content, attack angle, particle size, and particle velocity. Wear rate is established to be directly proportional to the velocity of the impacting particles. The angle of impact is also found to be an important factor in the dry wear rate, with highest erosion rates occurring at an about 45-deg impact angle; wear rates tapered off as the angles approached zero and 90 deg. In general, wear rate was not significantly affected by changing particle size. The percentage of reinforcement in the PEEK matrix proved to be directly proportional to the dry erosion rate. O.C.

A90-33344
SLIDING AND ABRASIVE WEAR BEHAVIOUR OF AN ALUMINUM (2014)-SIC PARTICLE REINFORCED COMPOSITE
A. T. ALPAS (Windsor, University, Canada) and J. D. EMBURY (McMaster University, Hamilton, Canada) Scripta Metallurgica et Materialia (ISSN 0956-716X), vol. 24, May 1990, p. 931-935. Research supported by NSERC and University of Windsor. refs
Copyright

The effect of SiC particles on the wear behavior of aluminum alloys is investigated, and the wear characteristics of particle reinforced composites are compared to those of conventional aluminum alloys under a variety of experimental conditions, including abrasive wear tests on Sic emery papers, dry sliding wear tests on hardened bearing steels, and lubricated sliding wear tests. The wear rates of the composite tested under different experimental conditions are summarized. It is shown that the highest wear rate is observed in the case of abrasive wear. The sensitivity of the wear rates of the alloys to the properties of counterfaces used and to the presense of interfacial elements in the tribosystems implies that the basic mechanisms of wear under the abrasive, dry, and lubricated conditions are different. N.B.

A90-33523
CYCLIC STRESS-STRAIN BEHAVIOR AND LOW CYCLE FATIGUE OF TI 6242
THANG QUOC-BUI, REHA GOMUC, ANDRE BIRON (Ecole Polytechnique, Montreal, Canada), HUU LUAN NGUYEN, and REDA N. TADROS (Pratt and Whitney Canada, Longueuil) Journal of Testing and Evaluation (ISSN 0090-3973), vol. 18, May 1990, p. 160-171. Research supported by the Ministere de l'Education du Quebec. refs
(Contract NSERC-A-4604)
Copyright

Results of strain-controlled fatigue tests at 329 C on Ti 6242, a potentially important material for aircraft engines, are reported. These tests were carried out under completely reversed strain conditions and with positive strains. Comparisons are made between the stress-strain relations obtained from monotonic tensile tests, at fast and slow strain rates, and those obtained from constant strain amplitude fatigue tests and from increasing multistep fatigue tests. The influence of induced mean stress is discussed. Author

A90-33701
DESIGNING WITH ADVANCED COMPOSITES; REPORT ON THE EUROPEAN CORE CONFERENCE, 1ST, ZURICH, SWITZERLAND, OCT. 20, 21, 1988, CONFERENCE PAPERS
Wilmington, DE, DuPont Nomex, 1988, 168 p. For individual items see A90-33702 to A90-33714.

The present conference discusses the development history of sandwich panel construction, production methods and quality assurance for Nomex sandwich panel core papers, the manufacture of honeycomb cores, state-of-the-art design methods for honeycomb-core panels, the Airbus A320 airliner's CFRP rudder structure, and the design tradeoffs encountered in honeycomb-core structures' design. Also discussed are sandwich-construction aircraft cabin interiors meeting new FAA regulations, the use of Nomex honeycomb cores in composite structures, a low-cost manufacturing technique for sandwich structures, and the Starship sandwich panel-incorporating airframe primary structure. O.C.

A90-33712#
REPAIRING THE DAMAGE
KEITH B. ARMSTRONG (British Airways, PLC, London, England) IN: Designing with advanced composites; Report on the European Core Conference, 1st, Zurich, Switzerland, Oct. 20, 21, 1988, Conference Papers. Wilmington, DE, DuPont Nomex, 1988, 17 p. refs

A great deal has been written and published about the design, construction, testing, materials of advanced composites, and especially about their use in aircraft and aerospace applications. This is not the case for their repair, which is evidently a much less 'glamorous' subject. Like metal parts, composite materials have to be repaired, since aircraft components are subject to damage in service. This article reviews the major parameters, products, methods currently used for repairing aircraft composites and case histories as experienced by British Airways. Author

A90-33985
HIGH-TEMPERATURE CORROSION AND MECHANICAL PROPERTIES OF SOME SILICON NITRIDE CERAMICS
M. VAN DE VOORDE, F. COSTA OLIVEIRA, and J. B. VEYRET (CEC, Joint Research Centre, Petten, Netherlands) IN: MRS International Meeting on Advanced Materials, 1st, Tokyo, Japan, June 2, 3, 1988, Proceedings. Volume 4. Pittsburgh, PA, Materials Research Society, 1989, p. 255-270. refs
Copyright

Structural ceramics are candidate materials for advanced engineering applications. These materials have to operate in corrosive environments under mechanical stresses at high temperatures. Corrosion, in particular reducing/sulphidizing environments, restricts the use of the best silicon nitrides to 1300 C. Carburization also damages Si3N4 at very high temperature and severe attack by molten salts was experienced at 1100 C. Silicon nitrides have been developed which may operate from a mechanical point of view up to 1400 C in air. Author

A90-33987
HOT-GAS CORROSION TEST OF SI3N4 AND SIC
SEIKI UMEBAYASHI, KAZUSHI KISHI, and KENJI MIYAZAKI (Government Industrial Research Institute, Tosu, Japan) IN: MRS International Meeting on Advanced Materials, 1st, Tokyo, Japan, June 2, 3, 1988, Proceedings. Volume 4. Pittsburgh, PA, Materials Research Society, 1989, p. 289-294.
Copyright

Results of a comparative study on the corrosion resistance of two silicon nitrides and silicon carbides with different sintering additives are presented. Samples were exposed to high temperature and high gas velocity flow conditions to simulate conditions in operating gas turbine engines. It is shown that the degradation of strength level after a hot corrosion test is much higher than that after a static oxidation test, and that different materials demonstrate different degrees of thickness and strength of the oxidation layer. N.B.

A90-34152* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
RESOURCES - SUPPLY AND AVAILABILITY
JOSEPH R. STEPHENS (NASA, Lewis Research Center, Cleveland, OH) IN: Superalloys, supercomposites and superceramics. San Diego, CA, Academic Press, Inc., 1989, p. 9-48. Previously announced in STAR as N87-21077. refs
Copyright

Over the past several decades there have been shortage of strategic materials because of our near total import dependence on such metals as chromium, cobalt, and tantalum. In response to the continued vulnerability of U.S. superalloy producers to disruptions in resource supplies, NASA has undertaken a program to address alternatives to the super-alloys containing significant quantities of the strategic materials such as chromium, cobalt, niobium, and tantalum. The research program called Conservation of Strategic Aerospace Materials (COSAM) focuses on substitution, processing, and alternate materials to achieve its goals. In addition to NASA Lewis Research Center, universities and industry play an important role in the COSAM Program. This paper defines what is meant by strategic materials in the aerospace community, presents a strategic materials index, and reviews the resource supply and availability picture from the U.S. point of view. In addition, research results from the COSAM Program are highlighted and future directions for the use of low strategic material alloys or alternate materials are discussed. Author

A90-34154
METALLURGY OF INVESTMENT CAST SUPERALLOY COMPONENTS
G. K. BOUSE (Howmet Technical Center, Whitehall, MI) and J. R. MIHALISIN (Howmet Corp., Alloy Div., Dover, NJ) IN: Superalloys, supercomposites and superceramics. San Diego, CA, Academic Press, Inc., 1989, p. 99-148. refs
Copyright

An account is given of the state-of-the-art in superalloy turbine blade and vane investment-casting technology. The process begins with the refining of a superalloy ingot to the requisite purity, and its subsequent remelting in the foundry furnace. The investment casting of superalloy components is differentiated into equiaxed vs directional grained structures, as well as conventional vs fine-grained equiaxed castings. Control of microstructure during solidification involves the growth of dendrites, carbides, eutectic segregation, and a degree of porosity. Postcasting processing possibilities encompass heat-treatment, HIPing, and weld-reworking. O.C.

A90-34156
THERMOMECHANICAL PROCESSING OF SUPERALLOYS
TIMOTHY E. HOWSON and WILFORD H. COUTS, JR. (Wyman-Gordon Co., Worcester, MA) IN: Superalloys, supercomposites and superceramics. San Diego, CA, Academic Press, Inc., 1989, p. 183-214. refs
Copyright

In the thermomechanical processing of superalloys such as Waspalloy, the deformation operation and the heat treatment applied are inextricably entwined. Current and prospective approaches to the specification of hot deformation process parameters are presented, and the issues that must be addressed in order to reproducibly control the selected process are discussed. The factors of supreme importance are billet chemistry, homogeneity, microstructure, and sonic penetrability, followed by the heating temperature and time and the strain rate, the workability of the material, and the allowable temperature gradients that result from adiabatic heating and heat losses to the work environment. O.C.

A90-34158
POWDER METALLURGY AND OXIDE DISPERSION PROCESSING OF SUPERALLOYS
JANINE C. BOROFKA, JOHN K. TIEN (Columbia University, New York), and ROBERT D. KISSINGER (GE Engineering Materials Technology Laboratories, Cincinnati, OH) IN: Superalloys, supercomposites and superceramics. San Diego, CA, Academic Press, Inc., 1989, p. 237-284. Research supported by USAF, NSF, and General Electric Co. refs
Copyright

P/M superalloy processing has reached a state of development at which such critical hot-section components as turbine disks have become dependent on P/M processing to achieve the requisite homogeneity and property reproducibility. An account is presently given of both gas atomization and centrifugal atomization techniques, mechanical alloying methods, and the design practices associated with consolidation containers and the methods of their use. Attention is given to the sources of P/M superalloy defects, and methods for their prevention and removal, as well as to the effects of thermomechanical processing. O.C.

A90-34162* Georgia Inst. of Tech., Atlanta.
CYCLIC DEFORMATION, FATIGUE AND FATIGUE CRACK PROPAGATION IN NI-BASE ALLOYS
STEPHEN D. ANTOLOVICH (Georgia Institute of Technology, Atlanta) and BRAD LERCH (NASA, Lewis Research Center, Cleveland, OH) IN: Superalloys, supercomposites and superceramics. San Diego, CA, Academic Press, Inc., 1989, p. 363-411. refs
Copyright

Ni-base superalloys' cumulative glide behavior, damage accumulation, low-cycle fatigue, and crack propagation characteristics are directly dependent on deformation behavior

which is in turn a strong function of microstructural characteristics. Microstructural instabilities and environmental interactions become additional factors at elevated temperatures. An account is presently given of microstructural, chemical, and processing techniques that may be used to obtain the properties that appear most critical or desirable in specific applications. O.C.

A90-34163
LIFE PREDICTION AND FATIGUE
MASAKI KITAGAWA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) IN: Superalloys, supercomposites and superceramics. San Diego, CA, Academic Press, Inc., 1989, p. 413-437. refs
Copyright

An account is given of research activities associated with high temperature superalloy fatigue life in Japan. The superalloys in question are typical of both gas turbine and high-temperature gas-cooled nuclear reactor applications, and encompass the Rene, Merl, Waspalloy, Hastelloy, and Inconel families. Attention is given to strain rate and temperature dependency relations, thermal fatigue life prediction, modifications to the linear creep fatigue damage summation rule, the characterization of crack propagation in superalloys, and the effects of directional solidification and HIP processing on gas turbine materials. O.C.

A90-34169* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FIBER REINFORCED SUPERALLOYS
DONALD W. PETRASEK, ROBERT A. SIGNORELLI (NASA, Lewis Research Center, Cleveland, OH), THOMAS CAULFIELD, and JOHN K. TIEN (Columbia University, New York) IN: Superalloys, supercomposites and superceramics. San Diego, CA, Academic Press, Inc., 1989, p. 625-670. Previously announced in STAR as N87-22811. refs
Copyright

Improved performance of heat engines is largely dependent upon maximum cycle temperatures. Tungsten fiber reinforced superalloys (TFRS) are the first of a family of high temperature composites that offer the potential for significantly raising hot component operating temperatures and thus leading to improved heat engine performance. This status review of TFRS research emphasizes the promising property data developed to date, the status of TFRS composite airfoil fabrication technology, and the areas requiring more attention to assure their applicability to hot section components of aircraft gas turbine engines. Author

A90-34681
DETERMINATION OF ADDITIVE CONTENTS IN AVIATION AND TURBINE OILS [OPREDELENIE SODERZHANIIA PRISADOK V AVIATSIONNYKH I TURBINNYKH MASLAKH]
V. N. BAKUNIN, I. B. KROTOVA, and A. I. ECHIN Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 4, 1990, p. 31-33. In Russian. refs
Copyright

A relatively simple and sufficiently accurate method for determining additive contents in oils using thin-layer chromatography is proposed. Details of the analysis are briefly described with particular reference to the determination of antioxidation additives in synthetic aviation oils and determination of Ionol in turbine oils. The relative accuracy of the method is estimated at 5.5-18.2 percent for 10 parallel tests. V.L.

A90-34990
MICROSTRUCTURES OF RAPIDLY-SOLIDIFIED BINARY TIAL ALLOYS
E. L. HALL and SHYH-CHIN HUANG (GE Corporate Research and Development Center, Schenectady, NY) Acta Metallurgica et Materialia (ISSN 0956-7151), vol. 38, April 1990, p. 539-549. refs
Copyright

The microstructures of rapidly-solidified melt-spun ribbons from binary Ti-Al alloys containing from 46 to 70 at. pct Al were investigated using optical and analytical transmission electron microscopy. It was found that, at 46 at. pct Al, an equiaxed alpha-2-Ti3Al was produced, with only a small amount of gamma-TiAl at grain boundaries, while at 48 at. pct Al, alloys were two-phase alpha-2-Ti3Al + gamma-TiAl, with the alpha-2 distributed either as particles or in a lamellar structure. Alloys from 50-52 at. pct Al were essentially single-phase gamma, while alloys from 53 to 55 at. pct were again two-phase alpha-2 + gamma, with the gamma being the primary solidification phase. At 60 at. pct Al, the alloy appeared to solidify as disordered fct or fcc gamma-TiAl, and then ordered upon cooling, producing antiphase boundaries in the gamma. At 70 at. pct Al, a two phase TiAl2 + TiAl3 microstructure was observed, with the latter phase occurring at the grain boundaries. I.S.

N90-20133* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE 1-(DIORGANOOXYPHOSPHONYL)-METHYL)-2,4- AND -2,6-DIAMIDO BENZENES Patent
JOHN A. MIKROYANNIDIS, inventor (to NASA) and DEMETRIUS A. KOURTIDES, inventor (to NASA) (National Academy of Sciences - National Research Council, Washington, DC.) 5 Sep. 1989 7 p Filed 28 May 1987 Division of US-Patent-4,689,421, US-Patent-Appl-SN-641152, filed 16 Aug. 1984; Continuation-in-part of US-Patent-Appl-SN-522629, filed 12 Aug. 1983, abandoned; Continuation-in-part of US-Patent-Appl-SN-493864, filed 12 May (NASA-CASE-ARC-11425-4; US-PATENT-4,864,050; US-PATENT-APPL-SN-054985; US-PATENT-APPL-SN-641152; US-PATENT-APPL-SN-522629; US-PATENT-APPL-SN-493864; US-PATENT-CLASS-558-190) Avail: US Patent and Trademark Office CSCL 07/1

1-((Diorgano oxyphosphonyl) methyl)-2,4- and -2,6-dinitro and diamino benzenes are prepared by nitrating an (organophosphonyl) methyl benzene to produce the dinitro compounds which are then reduced to the diamino compounds. The organo grounds (alkyl, haloalkyl, aryl) on the phosphorus may be removed to give the free acids (HO)2P(double bond O)single bond. The diamino compounds may be polymerized with dianhydrides or diacyl halides to produce fire and flame resistant polymers which are useful in the manufacture of aircraft structures.
Official Gazette of the U.S. Patent and Trademark Office

N90-20140# Rensselaer Polytechnic Inst., Troy, NY.
COMPENDIUM OF ABSTRACTS AND VIEWGRAPHS. Report, for 1 Dec. 1988 - 30 Nov. 1989
R. J. DIEFENDORF 30 Nov. 1989 549 p Presented at the 2nd International Workshop on Composite Materials and Structures for Rotorcraft, Troy, NY, 14-15 Sep. 1989
(Contract DAAL03-89-G-0003)
(AD-A217189; ARO-26588.1-EG-CF) Avail: NTIS HC A23/MF A03 CSCL 11/4

A workshop was conducted, dealing with the fundamentals of composite constituent materials and laminates as they influence applications to advanced rotorcraft developments. Included in the purview of the workshop were the theory, numerical analysis, fabrication, testing, and inspection of thermoset and thermoplastic resin matrix and metal matrix composites as they may have advantage for rotors, fixed airframe, drive system, controls, and engine cold section components. GRA

N90-20143# Michigan Univ., Ann Arbor. Dept. of Chemical Engineering.
SUMMARY REPORT OF THE SUMMER CONFERENCE OF THE DARPA-MATERIALS RESEARCH COUNCIL Report, 1 May 1987 - 30 Apr. 1990
M. J. SINNOTT 4 Aug. 1989 356 p Conference held in La Jolla, CA, 10 Jul. - 4 Aug. 1989
(Contract N00014-87-G-0217; DARPA ORDER 6029)
(AD-A217380) Avail: NTIS HC A16/MF A02 CSCL 05/2

The proceedings are presented for the conference. Some of the contents are: Fundamentals of Manufacturing Advanced Materials; DARPA Initiative to Establish a U.S. Base for Multi-Chip Module Substrates; U.S. Competitiveness in Ceramics; Mathematical Modeling; Designing with Advanced Composites; The

Fracture Energy of Metal/Ceramic Interfaces; Twin Induced Toughening in Gamma TiAL; The Critical Reinforcement Size for the Avoidance of Matrix Cracking; Advanced Composites with Improved Compressive Properties; Coatings for Fiber Reinforced Intermetallics; Interatomic Potentials; Refractory Compounds; Limitations of Processing Future VLSI Circuits; Advanced Packaging for Digital Silicon and GaAs; Sensors in Semiconductor Device Processing; Advanced Acoustic Sensors; Energetic Materials; Biomimetric Design; Neural Networks and Cellular Automata; Electrochemical Power Sources; Magnetic and Magnetoopitcal Recording; Photonic Manufacturing; Biotechnology; Jet Engines; Relative Reaction Rates of Methane Versus Acetylene in the Formation of C-13 Diamonds Films; Spectral Emissivities of Liquid Transition Metals as Functions of Temperature and wavelengths; and Advanced Systems for Adsorption of Toxic Gases. GRA

N90-20208# Pratt and Whitney Aircraft, West Palm Beach, FL.
IMPROVED TOUGHNESS ALLOYS BASED ON TITANIUM ALUMINIDES Final Report, Aug. 1985 - Mar. 1989
MARTIN J. BLACKBURN and MICHAEL P. SMITH 26 Oct. 1989 222 p
(Contract F33615-85-C-5030)
(AD-A218149; PW-FR-20760; WRDC-TR-89-4095) Avail: NTIS HC A10/MF A01 CSCL 21/5

Alloy development programs over the past decade have identified alloys, based on the compound Titanium aluminide (alpha-two) with tensile and creep properties that indicate applications at temperatures as high as 760 C (1400 F) should be possible. However, rather low values of toughness and impact resistance at temperatures less than 260 C (500 F) lead to concerns over component durability during assembly and service. The objective of this program was to improve the toughness of Ti3Al based alloys. In Phase I, solid solution modifications (Task 1), development of a tough second phase (Task 2), and formation of rare earth oxide dispersions by rapid solidification (Task 3) were investigated. Task 4 evaluated a combination of those alloys and processing techniques from the first three tasks. In Phase II, three alloy systems were selected for scale-up and extensive mechanical property testing. GRA

N90-20235# Scientific Computing Associates, Inc., New Haven, CT.
MODIFICATION AND IMPROVEMENT OF SOFTWARE FOR MODELING MULTIDIMENSIONAL REACTING FUEL FLOWS Final Report, 1 Nov. 1986 - 31 Jan. 1989
DAVID E. KEYES, DENNIS J. PHILBIN, and MITCHELL D. SMOOKE Jul. 1989 97 p
(Contract F33615-86-C-2694)
(AD-A217789; SCA-142; WRDC-TR-89-2056) Avail: NTIS HC A05/MF A01 CSCL 21/2

The flame type of most practical combustion devices is the diffusion flame. These flames are important in the interaction of heat and mass transfer with chemical reactions in ramjets, jet turbines and commercial burners. Three-dimensional models that couple the effects of fluid flow with detailed chemical reaction are as yet computationally infeasible. We focus our attention on axisymmetric laminar and turbulent diffusion flames in which a cylindrical fuel stream is surrounded by a coflowing oxidizer jet. In this configuration we can study the interaction of fluid flow with chemical reactions while obtaining a computationally feasible problem. The work centers on the development and application of accurate and efficient computational methods for the solution of the two-dimensional nonlinear boundary value problems describing the reacting systems. In particular, our goals involve the generalization of our one-dimensional fluid-chemistry model to two dimensions. We also focus on the use of two-dimensional flame sheet models as starting estimates for the nonlinear equation solver. Both confined and free methane-air flames have been studied. The results of the research are applicable to problems in: (1) turbulent reacting flows, (2) engine efficiency, (3) commercial power generation units, and (4) pollutant formation. GRA

N90-21137*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
STRUCTURAL TAILORING OF SELECT FIBER COMPOSITE STRUCTURES
CHRISTOS C. CHAMIS and ROBERT I. RUBINSTEIN (Sverdrup Technology, Inc., Cleveland, OH.) Feb. 1990 14 p Presented at the 45th Annual Conference on the Society of Plastics Industry Reinforced Plastics/Composites Inst., Washington, DC, 12-16 Feb. 1990
(NASA-TM-102484; E-5273; NAS 1.15:102484) Avail: NTIS HC A03/MF A01 CSCL 11/4

A multidisciplinary design process for aerospace propulsion composite structures was formalized and embedded into computer codes. These computer codes are streamlined to obtain tailored designs for select composite structures. The codes available are briefly described with sample cases to illustrate their applications. The sample cases include aircraft engine blades, propfans (turboprops), flat, and cylindrical panels. Typical results illustrate that the use of these codes enable the designer to obtain designs which meet all the design requirements with maximum benefits in efficiency, noise, weight or thermal distortions. Author

N90-21142# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
CRACK STOPPERS AND ARALL LAMINATES
J. SCHIJVE Mar. 1989 26 p
(PB90-166588; LR-589) Avail: NTIS HC A03/MF A01 CSCL 11/4

Tests were carried out on fatigue crack growth in 2024-T3 Alclad sheet specimens reinforced with strips. Strip materials were 2024-T3, 7075-T6, Ti-6Al-4V and ARALL. Adhesive bonded and riveted strips were used. Integral strips were tested for 2024-T3 only. Several observations were made on crack growth retardation caused by the strips. Adhesive bonding gives better results than riveting. The best strip materials were ARALL and the Ti-alloy. ARALL with advanced glass fibers are the most effective solution for crack stopper bands in a pressurized fuselage. Moreover, they offer less production problems. Author

N90-21188# Technology Assessment and Transfer, Inc., Annapolis, MD.
IMPROVED THERMO-OXIDATIVE-DEPOSITION SCREENING TESTS FOR TURBINE LUBRICANTS Final Report, Sep. 1986 - Jun. 1989
LARRY FEHRENBACHER, ROBERT SCHAFRIK, and JACQUELINE MACIA 12 Nov. 1989 79 p
(Contract F33615-86-C-2697)
(AD-A217795; WRDC-20) Avail: NTIS HC A05/MF A01 CSCL 11/8

This research applied combined Thermogravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC) techniques to establish a potential new laboratory screening method for simulating and differentiating the high temperature lubricant degradation phenomena of oils in operational turbine engines. GRA

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ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A90-31574
AN APPARATUS TO PREPARE COMPOSITES FOR REPAIR
EVERETT A. WESTERMAN and PHILLIP E. ROLL (Boeing Advanced Systems, Seattle, WA) IN: International SAMPE Symposium and Exhibition, 34th, Reno, NV, May 8-11, 1989,

Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 1041-1051.
Copyright

A fixture has been developed which can quickly and accurately prepare the damaged area in a composite structural component for either scarf or step method repairs. The apparatus involves a conventional router, router guides, a rotating assembly, and a vacuum-attachment mechanism; this configuration is fully adjustable for both scarf angle and depth of cut, and may be attached to any smooth surface with suction-cup feet. The mechanical scarfing apparatus has been demonstrated to reduce repair times by 50 percent, while increasing scarf-angle accuracy by 150 percent, for the cases of graphite/epoxy, graphite/BMI, and graphite/PEEK structural panels. O.C.

A90-31647
DAMAGE TOLERANCE OF A POSTBUCKLING SOFT SKIN HAT STIFFENED COMPRESSION PANEL

JAAP OLTHOFF (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: International SAMPE Symposium and Exhibition, 34th, Reno, NV, May 8-11, 1989, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1989, p. 2289-2300. Research sponsored by Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart. refs
Copyright

A general optimization program has been used to design a carbon/epoxy composite, soft-skinned, hat-stiffened compression panel able to withstand an ultimate compression design load of 1300 N/mm. The specimens constructed on this basis were found to be capable of withstanding up to 2.9 times the local buckling load without undergoing a failure strain due to separately inflicted impact damage. A disappointing drop in failure strain was noted, however, for separate stiffener specimens after impact; the toughened resin system employed does not appear to compensate for the inferior impact behavior of a highly oriented laminate. O.C.

A90-31879
FIBRE REINFORCED THERMOPLASTIC INTEGRAL CONSTRUCTIONS IN MODULAR BUILD-UP TECHNOLOGY - THE 'THERMOPLASTIC IN-SITU-TECHNIQUE'

GERHARD MUSCH and ERICH WINTERMANTEL (Zuerich, Eidgenoessische Technische Hochschule, Zurich, Switzerland) IN: Materials and processing - Move into the 90's; Proceedings of the Tenth International European Chapter Conference of SAMPE, Birmingham, England, July 11-13, 1989. Amsterdam, Elsevier Science Publishers, 1989, p. 21-28.
Copyright

A method has been developed whereby prefabricated thermoplastic components can be integrated into complex structures. The method involves in situ melting of the thermoplastic matrix, avoiding as far as possible the application of a complete autoclave cycle. The method is demonstrated by manufacturing a scaled-down (1:6) section of a highly integrated stinger-reinforced airframe structure. A newly developed vacuum forming machine, combined with a separable pressure vessel, will allow a cycle time of less than 15 min when applied to PEI and PPS. V.L.

A90-31881
AUTOMATED R.T.M. FOR AN AIRFRAME COMPONENT

IAN MARCHBANK (British Aerospace, PLC, Reinforced and Microwave Plastics Group, Stevenage, England) IN: Materials and processing - Move into the 90's; Proceedings of the Tenth International European Chapter Conference of SAMPE, Birmingham, England, July 11-13, 1989. Amsterdam, Elsevier Science Publishers, 1989, p. 75-86.
Copyright

A program is described whose objective was to adapt the traditional resin transfer molding (RTM) process to the high volume production of composite airframe components. The evolution of both design and manufacture leading to the production of full-scale prototype components is examined. The hybrid components, incorporating both low-density core materials and load-bearing inserts, have been successfully tested, and work is continuing toward flight trials. A description of an automated manufacturing facility proposed for the volume production of composite components by the RTM technique is presented. V.L.

A90-31892
DESIGN, FABRICATION AND EXPERIMENTAL TEST OF HI-TEMPERATURE CFRP STIFFENED STRUCTURES

DIDIER VIGNERON (Hispano-Suiza, Harfleur, France) IN: Materials and processing - Move into the 90's; Proceedings of the Tenth International European Chapter Conference of SAMPE, Birmingham, England, July 11-13, 1989. Amsterdam, Elsevier Science Publishers, 1989, p. 211-226.
Copyright

The use of a CFRP composite with a condensation reaction polyimide matrix for the fabrication of the rotating cowlings of an aircraft engine is discussed. A specific two-stage cure process (imidization and polymerization) has been used to cocure the laminate plies. The laminates show good mechanical performance with no microcracking. The discussion covers a description of the engine and access panels, design philosophy, process development, panel manufacturing, and results of static, vibration, and flight tests. V.L.

A90-32166
HEAT TRANSFER IN GAS TURBINE ENGINES; PROCEEDINGS OF THE SYMPOSIUM, ASME WINTER ANNUAL MEETING, SAN FRANCISCO, CA, DEC. 10-15, 1989

J. C. HAN, ED. (Texas A & M University, College Station) and R. E. MAYLE, ED. (Rensselaer Polytechnic Institute, Troy, NY) New York, American Society of Mechanical Engineers, 1989, 77 p. For individual items see A90-32167 to A90-32174.
Copyright

Topics presented include an experimental study of convective heat transfer in radially rotating rectangular ducts, an experimental study of heat transfer in a spanwise rotating channel turbulated with 45 deg. criss-cross ribs, local heat transfer on a flat surface roughened with broken ribs, and turbulent heat transfer and friction in a square channel with discrete rib turbulators. Also presented are simulating transitional flow and heat transfer over the flat plate and circular cylinder using a k-epsilon turbulence model, velocity and temperature profiles for stagnation film cooling, film cooling effectiveness in high turbulence flow, and local convection heat transfer on a plane wall in the vicinity of strong streamwise accelerations. R.E.P.

A90-32169
LOCAL HEAT TRANSFER ON A FLAT SURFACE ROUGHENED WITH BROKEN RIBS

M. K. CHYU and V. NATARAJAN (Carnegie-Mellon University, Pittsburgh, PA) IN: Heat transfer in gas turbine engines; Proceedings of the Symposium, ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 25-31. refs
Copyright

Detailed local mass(heat) transfer distributions are obtained for three different rib configurations, i.e., full transverse-rib, and broken ribs which may be either in-line or staggered, with pitch/rib height = 10 and 90-degree flow angle-of-attack. The study is performed using the naphthalene sublimation technique with a computer-controlled surface contour measurement system. Mass transfer characteristics for five periods are measured in both the developing and the developed regimes. The results show a fully developed periodic nature in the mass transfer starting after the second rib for all cases. The mass transfer in the first period is always the highest among all periods, and it displays greater spanwise variation than that in the developed regime. The broken rib, in general, produces lower mass transfer enhancement than the full rib. In the developed regime, the mass transfer enhancement for the full rib, broken in-line and broken staggered are 105 percent, 55 percent and 90 percent, respectively. Although

the heat transfer for the broken rib may be lower, the performance index which takes pressure drop into consideration could be advantageous over the full rib. Author

A90-32174
LOCAL CONVECTION HEAT TRANSFER ON A PLANE WALL IN THE VICINITY OF STRONG STREAMWISE ACCELERATIONS
B. J. STANEWICH and D. E. METZGER (Arizona State University, Tempe) IN: Heat transfer in gas turbine engines; Proceedings of the Symposium, ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 65-70. refs
Copyright

In unshrouded turbine stages in gas turbine engines, a stationary outer ring or shroud is used as a noncontacting seal to contain the hot gas flow within the desired path between the turbine blades. In normal operation a clearance gap exists between the blade tips and outer ring, and the hot gases are forced through the gap by the pressure difference between the blade pressure and suction sides. High levels of acceleration exist as the flow moves into the clearance gap from the pressure side of the blade passage, and as the flow accelerates into the gap it is expected that it will act to increase heat transfer on the adjacent outer ring segment as the velocity adjacent to the surface increases. This expected increase may be offset by the tendency for the flow to laminarize under the influence of strong acceleration, even though the acceleration length in the streamwise direction is short. An experimental study was designed and performed to model accelerating flow into a gap, and the results presented indicate that even very short lengths of acceleration produce large effects on the local convection heat transfer. Both acceleration and reverse transition appear to act together to produce a characteristic nonmonotonic variation in heat transfer. Author

A90-32263#
DESKTOP FAILURE ANALYSIS ON A MICROCOMPUTER USING WEIBULL, LOGNORMAL, AND RENEWAL DATA
J. L. BYERS (U.S. Navy, Naval Air Development Center, Warminster, PA) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 112, April 1990, p. 233-236.
(ASME PAPER 89-GT-275) Copyright

The U.S. Navy has developed and begun to use computer programs which implement gas turbine component failure mode analyses that correlate in either the Weibull or lognormal probability distributions. These programs, which enable designers and analysts to undertake such analyses interactively, in a user-friendly manner, with desktop hardware resources, are being expanded to cover virtually every area of the gas turbine life cycle requiring future-failure forecasting. The methods discussed are expected to be widely applicable outside the gas turbine field. O.C.

A90-32293* Akron Univ., OH.
A LASER BASED COMPUTER AIDED NON-INTRUSIVE TECHNIQUE FOR FULL FIELD FLOW CHARACTERIZATION IN MACROSCOPIC CURVED CHANNELS
M. J. BRAUN, V. A. CANACCI (Akron, University, OH), L. RUSSELL, and R. C. HENDRICKS (NASA, Lewis Research Center, Cleveland, OH) IN: Flow visualization - 1989; Proceedings of the Symposium, ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 15-22. refs
(Contract NCC3-93)
Copyright

This paper presents the application of a laser based, computer aided image processing technique for the nonintrusive evaluation of field velocities and accelerations in a 180 deg curved channel geometry, characteristic of inlet passages of the cowls of airbreathing aircraft engines. The method based on the illumination of the test section with a laser generated planar sheet of light, allows microscopic or macroscopic surveillance of fluid flow across or along large cross sections for relatively long (greater than 1 sec) periods of time. The method is Lagrangian in concept and permits identification and tracking of the same particle, thus facilitating construction of more comprehensive trajectories and the calculation of velocities and accelerations. Author

A90-32471*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NUMERICAL MODEL OF UNSTEADY SUBSONIC AEROELASTIC BEHAVIOR
THOMAS W. STRGANAC (NASA, Langley Research Center, Hampton, VA) and DEAN T. MOOK (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 28, May 1990, p. 903-909. Previously cited in issue 17, p. 2691, Accession no. A87-39640. refs
Copyright

A90-32475*# Maryland Univ., College Park.
STRUCTURAL OPTIMIZATION WITH AEROELASTIC CONSTRAINTS OF ROTOR BLADES WITH STRAIGHT AND SWEPT TIPS
R. CELI (Maryland, University, College Park) and P. P. FRIEDMANN (California, University, Los Angeles) (Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 2, p. 668-680) AIAA Journal (ISSN 0001-1452), vol. 28, May 1990, p. 928-936. Previously cited in issue 12, p. 1905, Accession no. A88-32247. refs
(Contract NAG2-226)
Copyright

A90-32504
HARNESSING DETAILED ASSEMBLY PROCESS KNOWLEDGE WITH CASE
WILLIAM J. MCCLAY and JOHN A. THOMPSON (Boeing Computer Services, Seattle, WA) IN: Innovative applications of artificial intelligence. Cambridge, MA, MIT Press, 1989, p. 159-168. refs
Copyright

The use of the connector assembly specifications expert system (CASE) to advise in the proper assembly of electric connectors is discussed. CASE is designed to answer a particular set of basic questions regarding any given connector assembly standard. The implementation and validation of CASE and the process of producing and maintaining knowledge bases are described. The process of providing CASE knowledge to other software systems and plans for future standards systems are considered. R.B.

A90-32675
INSTABILITY AND SUSCEPTIBILITY OF A BOUNDARY LAYER IN THE VICINITY OF TWO-DIMENSIONAL SURFACE INHOMOGENEITIES [NEUSTOICHIVOST' I VOSPRIIMCHIVOST' POGRANICHNOGO SLOIA V OKRESTNOSTI DVUMERNYKH NEODNORODNOSTEI POVERKHNOSTI]
A. V. BOIKO, A. V. DOVGAL', V. V. KOZLOV, and V. A. SHCHERBAKOV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Jan. 1990, p. 50-56. In Russian. refs
Copyright

The experimental study reported here was carried out in a low-turbulence subsonic wind tunnel with a maximum flow turbulence of 0.04 percent. The study focused on simple classical configurations: a forward-facing and a backward-facing step submerged into the boundary layer. In addition to the investigation of flow stability, the study was also concerned with the susceptibility of a boundary layer with elements of inhomogeneity to acoustic perturbations. It is shown that the backward-facing step (a step down) is more likely to cause the laminar-turbulent transition than the forward-facing step (a step up), which should be taken into account in aircraft design. V.L.

A90-32864
FIBER OPTICS SMART STRUCTURES PROGRAM AT UTIAS
RAY M. MEASURES (Toronto, University, Downsview, Canada) IN: Fiber optic smart structures and skins II; Proceedings of the

Meeting, Boston, MA, Sept. 5-8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 92-108. Research supported by NSERC, Ontario Centre of Excellence Program, and Ontario Laser and Lightwave Research Centre. refs
Copyright

Structurally integrated arrays of fiber-optic sensors could serve as an effective nervous system for future smart structures. The structural integrity of such structures would be monitored throughout their life, making obsolete the catastrophic failures that sometimes plague aircraft, trains, and cars. In addition the strain, deformation, vibration, and temperature state of these structures could also be monitored. A localized, all-fiber, dual-wavelength polarimetric fiber-optic sensor has been built and characterized. Also a localized, all-fiber, Michelson fiber-optic sensor that has measured the strain within a thermoplastic and detected the acoustic emission associated with delamination within a composite has been developed. It has been demonstrated that embedded optical fibers do not reduce the strength or damage resistance of composites but can detect load-induced growth of damage. The first fabrication of an aircraft composite leading edge with a built-in fiber-optic damage detection system has been completed. Author

A90-32871
DESIGN AND FABRICATION CONSIDERATIONS FOR COMPOSITE STRUCTURES WITH EMBEDDED FIBER OPTIC SENSORS
R. LEE WOOD (Textron Aerostructures, Nashville, TN), DALE A. WILSON (Tennessee Technological University, Cookeville), and ANDREW TAY IN: Fiber optic smart structures and skins II; Proceedings of the Meeting, Boston, MA, Sept. 5-8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 160-170.
Copyright

Design guidelines have been formulated, and both manual and automated fabrication-method development efforts have been undertaken, to produce laminated composite structures incorporating embedded fiber-optic sensors. The design guidelines are intended to establish the appropriate sensor, embedding location, and installation method for the variety of structures encountered in prospective applications. Photomicrographs of the results obtained to date are presented to illustrate these embedding techniques. A major goal of these efforts is a data base for both the effects of embedded devices on the structural integrity of the host components and the effects of layup and placement parameters on the embedded sensors' sensitivity and survivability. O.C.

A90-32885
APPLICATION OF EFFECTIVE BASELINES TO SMART STRUCTURES
MICHAEL BARRICK (LTV Corp., LTV Aircraft Products Group, Dallas, TX) IN: Fiber optic smart structures and skins II; Proceedings of the Meeting, Boston, MA, Sept. 5-8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 326-337.
Copyright

The development of an aircraft flight test program which uses a full smart-structure system to develop the baselines for all possible aircraft conditions is discussed. The mechanics of aircraft structural failures is briefly reviewed, and the measurement of parameters indicating structural problems is addressed. Candidate smart structure sensors are addressed, briefly describing the most important kinds. The general application of baselines to smart structures is discussed. It is concluded that the optimum processing system for smart-structure baselines uses a neural network which learns the baselines and is not dependent on specific algorithms. C.D.

A90-33375
IDENTIFICATION OF TIME VARYING MODAL PARAMETERS
J. E. COOPER (Royal Aerospace Establishment Farnborough, England) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 253-261. refs
Copyright

The ability to track time varying frequency and damping parameters using on-line versions of seven time domain system identification algorithms: Least Squares, Double Least Squares, Correlation Fit, Instrumental Variables, Instrumental Matrix with Delayed Observations, Extended Least Squares and Maximum Likelihood, is examined. Comparisons are made on results obtained from data generated from various simulated time varying systems, corrupted with both input and measurement noise, as a preliminary step before advancing onto real data. Only the Maximum Likelihood and Double Least Squares methods gave acceptable results on the most difficult data sets that were considered. The choice of an exponential weighting factor is crucial to the performance of the on-line methods when applied to data from time varying systems. The effect of assigning various values of the weighting factor is demonstrated. Further work is required to determine the optimum schemes for defining this parameter. Author

A90-33386#
HYDROELASTIC PROBLEMS IN SPACE FLIGHT VEHICLES
H. F. BAUER (Muenchen, Universitaet der Bundeswehr, Munich, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 359-367. refs

The hydroelastic behavior of an incompressible and frictionless liquid with a free surface has been presented for a cylindrical container. Coupled frequencies are presented for nonrotating and rotating containers. Through the coupling of liquid and structure the frequency may be removed from areas dangerous to the overall stability of the space vehicle. The instability of a rotating container may be removed by the inclusion of liquid. Author

A90-33391#
STRUCTURAL OPTIMIZATION IN VIEW OF AEROELASTIC CONSTRAINTS
PETER HEINZE, DETLEF SCHIERENBECK, and LUDWIG NIEMANN (MBB GmbH, Bremen, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 423-432. refs

A time-efficient procedure for calculation of aeraoelastic gradients with respect to the design variable is presented, and the reanalysis of the slightly changed structure is performed. Whereas flutter velocity is normally used as a constraint, i.e., as in the FASTOP program, this procedure utilizes damping as well as velocity as a constraint. The main advantages are: even structures which have no real zero damping up to 1.2 Vd can be optimized and hump modes can be manipulated. In the domain of steady aeroelasticity, additional control surface effectiveness is introduced at constraint. The application of an aeroelastic optimization in combination with a commercial structural optimizer for a large transport aircraft is demonstrated. Author

A90-33396
SENSITIVITY ANALYSIS USING RESONANCE AND ANTI-RESONANCE FREQUENCIES - A GUIDE TO STRUCTURAL MODIFICATION
G. W. SKINGLE and D. J. EWINS (Imperial College of Science, Technology, and Medicine, London, England) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 473-478. Research supported by the Ministry of Defence. refs
Copyright

In attempts to improve the dynamic behavior of a structure, techniques are used to predict the response of the structure with various different modifications. The process by which a modification is selected and designed initially can be made more efficient if

the sensitivities of points on the structure to simple types of modification are known. The intention is to select the most effective type of modification at the earliest possible stage. A new method for calculating the mode sensitivities to single degree-of-freedom mass or stiffness modifications is presented in this paper. The method is readily implemented, and is based on the use of resonance and anti-resonance frequencies of the original unmodified structure. The sensitivity characteristics produced enable the degree-of-freedom to be ranked in order of importance for modification, for each mode of vibration. Author

A90-33424
CALCULATION OF FLOW ON A FLAT PLATE AT ANGLE OF ATTACK BY NUMERICAL SOLUTION OF NAVIER-STOKES EQUATIONS [CALCUL DE L'ECOULEMENT SUR UNE PLAQUE PLANE EN INCIDENCE PAR RESOLUTION NUMERIQUE DES EQUATIONS DE NAVIER-STOKES]
PASCAL GENDRE (Centre Europeen de Recherche et de Formation Avancee en Calcul Scientifique, Toulouse, France) Revue Scientifique et Technique de la Defence (ISSN 0994-1541), no. 6, 4th Quarter, 1990, p. 85-96. In French. refs
Copyright
A Navier-Stokes solver is proposed which is based on a finite volume hybrid scheme, on a fully implicit solution of the linear set of equations obtained after discretization, and on the mixing length closure model. It has been tested on the configuration of a flat plate placed at 4 degrees of incidence in a low speed flow, with the Reynolds number based on the chord length being equal to 200,000. Promising results were obtained. Author

A90-33555*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
AN ANNULAR GAS SEAL ANALYSIS USING EMPIRICAL ENTRANCE AND EXIT REGION FRICTION FACTORS
D. A. ELROD (Virginia Polytechnic Institute and State University, Blacksburg), D. W. CHILDS, and C. C. NELSON (Texas A & M University, College Station) (STLE and ASME, Joint Tribology Conference, Fort Lauderdale, FL, Oct. 16-19, 1989) ASME, Transactions, Journal of Tribology (ISSN 0742-4787), vol. 112, April 1990, p. 196-204. refs
(Contract NAG3-181)
(ASME PAPER 89-TRIB-46) Copyright
Wall shear stress results from stationary-rotor flow tests of five annular gas seals are used to develop entrance and exit region friction factor models. The friction factor models are used in a bulk-flow seal analysis which predicts leakage and rotor-dynamic coefficients. The predictions of the analysis are compared to experimental results and to the predictions of Nelson's analysis (1985). The comparisons are for smooth-rotor seals with smooth and honeycomb-stators. The present analysis predicts the destabilizing cross-coupled stiffness of a seal better than Nelson's analysis. Both analyses predict direct damping well and direct stiffness poorly. Author

A90-33556#
TEST RESULTS FOR TURBULENT ANNULAR SEALS, USING SMOOTH ROTORS AND HELICALLY GROOVED STATORS
D. W. CHILDS (Texas A & M University, College Station), S. A. NOLAN (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA), and J. J. KILGORE (Shell Development Westhollow Research Center, Houston, TX) (STLE and ASME, Joint Tribology Conference, Fort Lauderdale, FL, Oct. 16-19, 1989) ASME, Transactions, Journal of Tribology (ISSN 0742-4787), vol. 112, April 1990, p. 254-258. refs
(ASME PAPER 89-TRIB-11) Copyright
Test results, consisting of leakage data, friction factors, and rotordynamic force coefficients, are presented for seven annular seals using smooth rotors and helically-grooved stators. All seals have the same nominal clearances and groove depths. The helix angles vary from zero (circumferential grooving) to 70 deg. The number of grooves and the leakage rates increase steadily with increasing helix angles. Helically-grooved stators leak more than smooth seals for helix angles greater than 30 deg. The effective direct stiffness of the seals first decreases and then increases with increasing helix angles. Contrary to theoretical predictions (Kim and Childs 1987), the effective net damping was relatively insensitive to changes in the helix angles. Author

A90-33557#
ENDURANCE OF AIRCRAFT GAS TURBINE MAINSHAFT BALL BEARINGS-ANALYSIS USING IMPROVED FATIGUE LIFE THEORY. I - APPLICATION TO A LONG-LIFE BEARING
E. IOANNIDES (SKF Engineering and Research Centre, Nieuwegein, Netherlands), T. A. HARRIS, and M. RAGEN (MRC Bearings, Jamestown, NY) ASME, Transactions, Journal of Tribology (ISSN 0742-4787), vol. 112, April 1990, p. 304-308. refs
Copyright
The performance of a mainshaft ball bearing in a high-performance aircraft gas turbine engine was evalated using an improved fatigue life theory of Ioannides and Harris (1985), and the results were compared with those calculated by methods defined in the ANSI and ISO standards. It is demonstrated that, by using the new theory, together with an appropriate fatigue limit for the bearing's VIMVAR M50 steel rings, the extremely long endurance of the bearing (more than 200,000 hrs L10 life) could be reasonably predicted. On the other hand, when the ANSI and ISO rating methods were applied, the bearing fatigue endurance was underestimated by a factor of more than 100. I.S.

A90-33566#
THE USE OF CIRCUMFERENTIALLY VARYING STAGGER GUIDE VANES IN AN AXIAL FLOW PUMP OR COMPRESSOR
J. H. HORLOCK (Open University, Milton Keynes, England) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 112, April 1990, p. 294-297.
Copyright
An actuator disk analysis is given of the flow through a guide vane and rotor combination. It is shown that changes in total pressure across the rotor are, in general, related to circumferential variations in guide vane outlet angle. In particular, known variations in inlet total pressure may be eliminated by suitable circumferential changes in guide vane stagger. Author

A90-33597
ESTIMATION OF LOSSES IN SEMI-OPEN CENTRIFUGAL IMPELLERS
A. ENGEDA and M. RAUNTENBERG (Hannover, Universitaet, Hanover, Federal Republic of Germany) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 6, no. 2, 1989, p. 183-188. refs
Copyright
In centrifugal impellers of the semiopen type (impellers without front shroud), the clearance between the vanes and the stationary casing, known as tip clearance, has a deciding role on the overall performance of the machine. Tip clearance flows are an important source of turbomachinery energy loss. The deterioration of compressor and pump performance due to tip clearance, are often found in the literature, expressed in different ways with widely varying coefficients, depending on machine and fluid type. Practice shows these relationships to be unreliable, since most of them are based on simplified flow models where the impact of the simplifications are also unknown. Some of these relationships and the merits and setbacks of each are studied. Author

A90-33624
INVESTIGATION OF VARIATION IN FATIGUE LIFE CALCULATED USING DAMAGE FRACTION
CLIFFORD T. GUNSALLUS, EDWARD NAGY, PATRICK G. STENNETT, and WILLIAM G. FLANNELLY (Kaman Aerospace Corp., Bloomfield, CT) American Helicopter Society, Journal (ISSN 0002-8711), vol. 35, April 1990, p. 35-41. refs
(Contract DAAJ02-85-C-0048)
Copyright
This paper identifies the leading causes for large variations in the calculated fatigue lives of the hypothetical pitch link experiment

of the American Helicopter Society, conducted in cooperation with all U.S. manufacturers of military helicopters. Multivariate Analysis of Variance (MANOVA) is used to show that approximately 85 percent of the variations can be attributed to only two of the five analytical steps involved and the interactions between them. These steps are the method of cycle counting and the amount of S/N curve reduction. Author

A90-33698* Vigyan Research Associates, Inc., Hampton, VA.
ON DYNAMIC STABILITY BOUNDARIES FOR BINARY SYSTEMS
M. I. YOUNG (Vigyan, Inc., Hampton, VA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 136, Feb. 8, 1990, p. 522-524.
(Contract NAS1-18585)
Copyright

Dynamic stability boundaries are developed for linear two-degree-of-freedom systems with damping and elastic couplings. Special emphasis is placed on the influence of natural frequency proximity and those instabilities which stem from skew-symmetric stiffness properties. These arise in aeroelasticity and flight dynamics systems. Insight is provided into the destabilizing effects of the 'dreaded modal resonance' which results when the two natural frequencies in the modal natural frequency ratio match or nearly match. S.A.V.

A90-33702#
THE STORY OF SANDWICH CONSTRUCTION
HOWARD G. ALLEN (Southampton, University, England) IN: Designing with advanced composites; Report on the European Core Conference, 1st, Zurich, Switzerland, Oct. 20, 21, 1988, Conference Papers. Wilmington, DE, DuPont Nomex, 1988, 24 p. refs

The requirements of an ideal sandwich are described and it is shown how closely modern types of core material approach the ideal. The early developments in sandwich construction are described, including ideas for novel types of core. The essential features of linear elastic theory and of wrinkling theory are summarized. The increasing importance of finite element analysis since the early seventies is stressed. Author

A90-33704#
MANUFACTURE OF HONEYCOMB
JOHN L. CORDEN (Hexcel Corp., Dublin, CA) IN: Designing with advanced composites; Report on the European Core Conference, 1st, Zurich, Switzerland, Oct. 20, 21, 1988, Conference Papers. Wilmington, DE, DuPont Nomex, 1988, 9 p.

An overview of the terminology used in the honeycomb industry is given as background information as well as a description of the various cell configurations currently in use. With the explanation of the basic terminology and cell configurations in place, the primary and secondary processes used to fabricate honeycomb core materials is discussed. Primary processing is used to convert web materials into flat honeycomb sheets while secondary processing is used to convert flat honeycomb sheets into core parts ready for bonding. Author

A90-33705#
HONEYCOMB QUALITY REQUIREMENTS - A USER'S PERSPECTIVE
PETER FORNELL (MBB GmbH, Hamburg, Federal Republic of Germany) IN: Designing with advanced composites; Report on the European Core Conference, 1st, Zurich, Switzerland, Oct. 20, 21, 1988, Conference Papers. Wilmington, DE, DuPont Nomex, 1988, 17 p.

This paper discusses quality requirements for Nomex honeycomb as perceived by a user in the area of civil aeronautics construction. Quality problems resulting from certain Nomex core defects are explained, and suggestions for the improvement of this remarkable material are given. Author

A90-33706#
DESIGN WITH HONEYCOMB, STATE OF THE ART
MARTIN HOLLMANN (Aircraft Designs, Inc., Cupertino, CA) IN: Designing with advanced composites; Report on the European Core Conference, 1st, Zurich, Switzerland, Oct. 20, 21, 1988, Conference Papers. Wilmington, DE, DuPont Nomex, 1988, 8 p.

The safe use of honeycomb-core composite panels entails proper sizing in order to ensure the intended service life. Such sizing can be performed by hand for simple components of through the use of FEM analysis for more complex ones; the availability of such FEM software for structural modeling is essential for such cases as that of all-honeycomb sandwich airframe structure, where numerous redundant load-paths exist. A comparison is presented between engineering mechanics calculations and computerized FEM analysis results obtained on a PC, for the case of a honeycomb-core beam. O.C.

A90-33708#
TRADEOFFS IN HONEYCOMB CORED DESIGNS
HALVAR Y. LOKEN (Du Pont de Nemours and Co., Fibers Dept., Wilmington, DE) IN: Designing with advanced composites; Report on the European Core Conference, 1st, Zurich, Switzerland, Oct. 20, 21, 1988, Conference Papers. Wilmington, DE, DuPont Nomex, 1988, 13 p.

The present consideration of design tradeoffs typically encountered during the initial evaluation of a honeycomb-core structures gives attention to both the advantages of this type of construction for a simple structural element, namely a flat beam in three-point bending, and the actual preliminary design process for an entire large transport aircraft rudder, with a view to honeycomb's comparative advantages over more conventional structural methods. In the latter case, the honeycomb core approach employs Nomex honeycomb and kevlar/epoxy skins; the comparable conventional structure case is a rib-stiffened design with graphite/epoxy skins. O.C.

A90-33775
THE AIRBORNE SUPERCOMPUTER
JOHN RHEA Air Force Magazine (ISSN 0730-6784), vol. 73, May 1990, p. 162-165, 167.
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A new class of airborne supercomputer designated RH-32 is being developed at USAF research facilities, capable of performing the critical battle management function for any future antiballistic missile system that emerges from the SDI. This research is also aimed at applications for future tactical aircraft and retrofit into the supercomputers of the ATF. The computers are based on a system architecture known as multi-interlock pipe stages, developed by the DARPA. Fiber-optic data buses appear to be the only communications media that are likely to match the speed of the processors and they have the added advantage of being inherently radiation resistant. The RH-32 itself, being the product of a basic research effort, may never see operational use. However, the technologies that emerge from this major R&D program will set the standards for airborne computers well into the next century. R.E.P.

A90-33897*# Scientific Research Associates, Inc., Glastonbury, CT.
FLUORESCENCE SPECTROSCOPY AND THERMOMETRY FOR HYPERSONIC FLIGHT RESEARCH
B. E. THOMPSON, S. M. FERNANDEZ, and E. F. GUIGNON (Scientific Research Associates, Inc., Glastonbury, CT) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 101-112. refs
(Contract NAS1-18804)
(AIAA PAPER 90-1272) Copyright

The present study, which has demonstrated the feasibility of using time-resolved laser-induced fluorescence methods to ascertain boundary layer temperature distributions in real time for hypersonic vehicles in atmospheric flight, employs conventional optics in combination with novel time-resolved spectroscopy. The radiative lifetime and signal intensity involved, both of which are reduced by quenching, are adequate for measurement with

state-of-the-art time-resolved fluorescence techniques, except for certain conditions associated with both the highest speeds and the lowest altitudes. O.C.

A90-34229#
HOT WIRE ANEMOMETRY IN TRANSONIC FLOWS AND CRYOGENIC CONDITIONS
P. C. STAINBACK and F. K. OWEN (Complere, Inc., Palo Alto, CA) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 10 p. refs

A technique which is believed to measure the correct levels for fluctuations of velocity, density and total temperature in transonic flows is described. Examples of these and other statistical quantities were presented for the Langley Research Center 0.3 m Transonic Cryogenic Tunnel. An error analysis for single and multiple wire hot wire probes is offered and results indicate that data obtained using single or dual wire probes can be in error. Finally, some of the problems associated with obtaining hot wire data at transonic speeds at cryogenic conditions are discussed. R.E.P.

A90-34231#
FORCE BALANCE ERRORS DUE TO TEMPERATURE CHANGES IN ETW
W. B. BALD (York, University, England) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 13 p. Research supported by the Department of Trade and Industry. refs

Previous work has shown that heated balances are unacceptable for use in ETW. More recent investigations have also shown that using the complete model-balance-sting assembly to predict force changes in balances directly from changes in stream temperature is also inaccurate. An alternative approach including a thermal load analysis on the simple RAE gauge link balance is prsented here and compared with measured transient load changes. It is found that attempting to predict the temperature-induced force balance changes in ETW by thermally modeling the complete model-balance-sting assembly itself, rather than measuring changes in stream temperature, will also lead to unacceptable errors. The number of temperature sensors required to monitor thermal transients within the balance itself can be minimized by using finite element modeling of the balance together with an appropriate measured boundary condition. C.D.

A90-34234*# Southampton Univ. (England).
SURFACE FLOW VISUALIZATION IN THE CRYOGENIC WIND TUNNEL
M. J. GOODYER (Southampton, University, England) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 18 p. Research supported by the University of Southampton. refs
(Contract NAS1-17919)

The prospects are reviewed of a range of possible surface flow visualization methods for application to model testing in the large cryogenic wind tunnel. Desirable features are outlined, including the flow details which should be revealed by the various methods. The risks of model and tunnel contamination are discussed, also the coverage of the model surface to be expected, the advance planning and complexity of model design and tunnel equipment required by the visualization method, and the prospects of generating multiple flow images during one tunnel run. The techniques range from the untried to several on which already there is some experience in the cryogenic environment. Directions for further development are suggested. Author

A90-34235#
MODEL ATTITUDE MEASUREMENT SYSTEM
G. RIVET and M. LEQUIME (Bertin et Cie., Les Milles, France) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 11 p. refs

An optical system for accurately measuring the attitude of a model being tested inside a transonic wind tunnel is described. The system sensitivity is presented and a quantitative analysis of the Moire effect applied to the system's optical reflector is given. The system is particularly attractive for application to angle variation measurements. Its performance in terms of sensitivity and linearity is good and the reflector assembly, being a passive device, is not too sensitive to the environment. C.D.

A90-34236#
A DYNAMIC OPTICAL MODEL ATTITUDE MEASUREMENT SYSTEM
F. K. OWEN, G. M. ORNGARD, T. K. MCDEVITT, and T. A. AMBUR (Complere, Inc., Palo Alto, CA) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 21 p.

A major source of transonic wind tunnel test data uncertainty is due to angle of attack measurement errors caused by unknown sting and balance deflections under load. Since dynamic loads in the ETW will greatly exceed those in conventional wind tunnels, the need to account for these distortions during model testing will be even more acute. The correct determination of angle of attack will require in situ measurements so that model deflections and tunnel wall movements due to changes in freestream dynamic pressure and temperature can be accounted for. To meet this challenge, a novel, laser-based instrument for the in situ measurement of wind tunnel model angle of attack in the ETW is proposed. The sensor will enable continuous, time-dependent measurements to be made without signal dropout. The instrument will be inexpensive, compact and robust and will work when intermittent fog is present. Sensitivities of 0.01 deg will be possible. The purpose of this research is to determine the feasibility of using this instrument for model attitude measurements in the ETW and to establish design and installation criteria consistent with wind tunnel constraints. Author

A90-34239#
FEASIBILITY STUDY OF RADAC STEREO OPTOELECTRONIC MODEL DEFORMATION MEASUREMENT SYSTEM FOR ETW
B. LAMISCARRE, CH. LEMPEREUR (ONERA, Centre d'Etudes et de Recherches de Toulouse, France), and J. C. PASQUET (Intespace, Toulouse, France) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 6 p.

This paper summarizes the feasibility study of RADAC stereo optoelectronic model deformation measurement system for ETW. The principles of the RADAC system and of its implementation are summarized. User requirements, model-related requirements, environmental requirements, operational requirements are outlined, as are the RADAC optical principle, acquisition and processing chain principle, and models deformation measurements principle. C.D.

A90-34249#
AN INFRARED CAMERA SYSTEM FOR DETECTION OF BOUNDARY LAYER TRANSITION IN THE ETW
B. SCHULZE, R. LANGE, and S. CRAUBNER (MBB GmbH, Munich, Federal Republic of Germany) European Transonic Windtunnel GmbH and DFVLR, Cryogenic Technology Meeting, 2nd, Cologne, West Germany, June 28-30, 1988, Paper. 18 p. refs

Infrared radiometry/thermography is a feasible test technique for surface flow visualization in the European Transonic Windtunnel (ETW), especially for detection of boundary layer transition contours on model surfaces. This technique applies remote sensing of infrared radiation from thermal surface patterns corresponding to specific surface flow phenomena, e.g. boundary layer transition. In order to meet increased requirements at cryogenic temperatures compared to ambient conditions, special detection equipment will be needed. A complete infrared radiometer camera system for ETW operating at temperatures between 100 and 300 K is

described considering a cooled extrinsic detector, a dynamic optical focus and a flexible scanning schedule for individual model dimensions. Author

A90-34324#
THREE DIMENSIONAL TURBINE BLADE ANALYSIS IN THERMO-VISCOPLASTICITY
M. GERADIN, J. C. GOLINVAL (Liege, Universite de l'Etat, Belgium), and J. P. MASCARELL (SNECMA, Moissy-Cramayel, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 5, 1989, p. 51-57. refs
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Unified elasto-viscoplastic constitutive equation models have been implemented in a general purpose finite element code used in an industrial context for the stressing of structures submitted to high cyclic loading levels. Continuum damage model is used for the lifetime prediction of structures. This paper illustrates the use of these models on a three-dimensional turbine blade analysis regarding the calculations of stress redistributions during the loading cycles and the lifetime prediction. The three-dimensional solution is compared to the solution found with the classical uniaxial plane cross-section assumption. Author

A90-34352
EXAMPLES OF FORCE MEASUREMENTS IN A WIND TUNNEL USING MULTICOMPONENT PIEZOELECTRIC TRANSDUCERS [BEISPIELE FUER KRAFTMESSUNGEN IM WINDKANAL MIT PIEZOELEKTRISCHEN MEHRKOMPONENTENMESSELEMENTEN]
G. SCHEWE (DLR, Goettingen, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 14, no. 1-2, 1990, p. 32-37. In German. refs
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Several wind-tunnel balances based on multicomponent piezoelectric force transducers are described. These balances have been used previously for several tests such as a fin/rudder model in a transonic wind tunnel, an ejector engine in low-speed and transonic wind tunnels, measurements on two-dimensional sections in a high-pressure wind tunnel, and an Airbus wing model (including engine) in a low-speed wind tunnel. These examples give an impression of the effective measuring times for static applications and the accuracy which can be achieved. Author

A90-34385* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPUTATIONAL FLUID DYNAMICS - CURRENT CAPABILITIES AND DIRECTIONS FOR THE FUTURE
PAUL KUTLER (NASA, Ames Research Center, Moffett Field, CA) IN: Supercomputing '89; Proceedings of the Second Conference, Reno, NV, Nov. 13-17, 1989. Washington, DC/New York, IEEE Computer Society/ACM Press, 1989, p. 113-122. refs
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Computational fluid dynamics (CFD) has made great strides in the detailed simulation of complex fluid flows, including some of those not before understood. It is now being routinely applied to some rather complicated problems and starting to affect the design cycle of aerospace flight vehicles and their components. It is being used to complement, and is being complemented by, experimental studies. Several examples are presented in the paper to illustrate the current state of the art. Included is a discussion of the barriers to accomplishing the basic objective of numerical simulation. In addition, the directions for the future in the discipline of computational fluid dynamics are addressed. I.E.

N90-20312# Wright State Univ., Dayton, OH. Dept. of Electrical Engineering.
INTEGRATED CIRCUITS FOR AVIONICS Final Report, Jul. 1985 - Jun. 1989
RAYMOND SIFERD Oct. 1989 123 p
(Contract F33615-85-C-1718; AF PROJ. 7662)
(AD-A217964; WRDC-TR-89-1118) Avail: NTIS HC A06/MF A01 CSCL 09/1

The main thrust of the Integrated Circuits for Avionics Program is to calibrate the chip area requirements and performance that can be obtained from custom VLSI circuits which were designed to accomplish a specific communication signal processing task. The two primary areas of investigation were stringent narrow band filtering based on highly parallel VLSI systolic array architectures and vector processors based on the residue number theory and highly parallel VLSI pipelined architectures. Designs are included for custom VLSI programmable filters in both NMOS and CMOS technologies along with measured performance of higher order filters resulting from cascading the custom prototype chips. A unique multirate sampling scheme is presented for improving filter response. A unique custom VLSI design is included for a high performance pipelined residue processor using 16-bit operands and providing 32-bit results. Measured performance of this architecture is also included based upon testing of a prototype custom VLSI circuit. GRA

N90-20325*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ANALYSIS OF SMALL-SCALE ROTOR HOVER PERFORMANCE DATA
CAHIT KITAPLIOGLU Mar. 1990 27 p
(NASA-TM-102271; A-90046; NAS 1.15:102271) Avail: NTIS HC A03/MF A01 CSCL 20/4

Rotor hover-performance data from a 1/6-scale helicopter rotor are analyzed and the data sets compared for the effects of ambient wind, test stand configuration, differing test facilities, and scaling. The data are also compared to full scale hover data. The data exhibited high scatter, not entirely due to ambient wind conditions. Effects of download on the test stand proved to be the most significant influence on the measured data. Small-scale data correlated resonably well with full scale data; the correlation did not improve with Reynolds number corrections. Author

N90-20345# Pennsylvania State Univ., University Park. Dept. of Mechanical Engineering.
DURIP OPTICAL EQUIPMENT FOR HIGH-SPEED VISCOUS-INVISCID INTERACTION RESEARCH Final Report, 1 Dec. 1988 - 30 Nov. 1989
GARY S. SETTLES 5 Jan. 1990 9 p
(Contract AF-AFOSR-0140-89; AF PROJ. 2307)
(AD-A217772; AFOSR-90-0074TR) Avail: NTIS HC A02/MF A01 CSCL 20/4

The Penn State Gas Dynamics Lab has an active, ongoing program in experimental high speed fluid dynamics research. The current research of the Laboratory concerns supersonic viscous/inviscid interactions, compressible turbulent mixing, and high speed vortex dynamics pertaining to external and internal aerodynamics and propulsion. The Laboratory specializes in development and use of advanced, non-intrusive optical flow diagnostics in such research studies. These optical instruments and techniques are brought to bear on basic fluid dynamic experiments in the Penn State Supersonic Wind Tunnel, which has a high Reynolds number capability and continuously-variable Mach number range of Mach 1.5 to 4.0. GRA

N90-20346# Colorado Univ., Boulder. Dept. of Aerospace Engineering Sciences.
EXPERIMENTAL INVESTIGATION OF THE MECHANISMS UNDERLYING VORTEX KINEMATICS IN UNSTEADY SEPARATED FLOWS Ph.D. Thesis
SCOTT JEFFREY SCHRECK 1989 157 p Sponsored by AFIT, Wright-Patterson AFB, OH
(AD-A217889; AFIT/CI/CIA-89-149) Avail: NTIS HC A08/MF A01 CSCL 20/4

Unsteady separated flow fields in the vicinity of a flat plate oscillating sinusoidally in pitch about the quarterchord were investigated for a broad range of pitching parameters. Phase locked photography of smoke flow visualization was employed in conjunction with hotwire anemometry to quantify vortex development as well as some of the primary boundary layer interactions contributing to the observed vortex kinematics. Leading

edge vortex development was strongly influenced by both the freestream and boundary layer flows. These and other observations facilitated formulation of an conceptual model which accounts for many of these observations. Quantitative refinement of such a model is one methodology through which unsteady separation may eventually be understood, predicted and controlled for employment in future air vehicles. GRA

N90-20349# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
A MATRIX-FREE LOCALLY-IMPLICIT SCHEME FOR NAVIER-STOKES EQUATIONS M.S. Thesis - Tennessee Univ., Knoxville
MATTHEW C. TOWNE May 1989 53 p
(AD-A218298; AFIT/CI/CIA-89-050) Avail: NTIS HC A04/MF A01 CSCL 20/4

A locally-implicit scheme for steady-state solution of the thin-layer Navier Stokes Equations is simplified by elimination of coefficient matrices. This reduces both arithmetic computation and computer storage requirements. An added benefit is the simplification of the algorithm which eases the coding task. The locally-implicit scheme uses finite-volume spatial discretization, locally implicit time integration, Jameson-type artificial dissipation terms and a modified Gauss Seidel iteration. The modified method is tested for subsonic and transonic flows over an RAE 2822 airfoil. GRA

N90-20392*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AN APPLICATIONAL PROCESS FOR DYNAMIC BALANCING OF TURBOMACHINERY SHAFTING
VINCENT G. VERHOFF Mar. 1990 36 p
(NASA-TM-102537; E-4768; NAS 1.15:102537) Avail: NTIS HC A03/MF A01 CSCL 13/9

The NASA Lewis Research Center has developed and implemented a time-efficient methodology for dynamically balancing turbomachinery shafting. This methodology minimizes costly facility downtime by using a balancing arbor (mandrel) that simulates the turbomachinery (rig) shafting. The need for precision dynamic balancing of turbomachinery shafting and for a dynamic balancing methodology is discussed in detail. Additionally, the inherent problems (and their causes and effects) associated with unbalanced turbomachinery shafting as a function of increasing shaft rotational speeds are discussed. Included are the design criteria concerning rotor weight differentials for rotors made of different materials that have similar parameters and shafting. The balancing methodology for applications where rotor replaceability is a requirement is also covered. This report is intended for use as a reference when designing, fabricating, and troubleshooting turbomachinery shafting. Author

N90-20434# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
ROTORDYNAMIC ANALYSIS WITH SHELL ELEMENTS FOR THE TRANSFER MATRIX METHOD M.S. Thesis
EDWARD A. LANTIGUA Aug. 1989 179 p
(AD-A217455; AFIT/CI/CIA-89-111) Avail: NTIS HC A09/MF A01 CSCL 20/11

Shell finite elements were used to model conical sections with a range in parameters; axial length, radius, wall thickness, cone angle and Young's modulus. The parameters were chosen to cover the complete range of rotors, casings, and housings used throughout the turbomachinery industry. Flexibility coefficients were generated for these structures. The need for these flexibilities to be used in the current day rotor dynamics transfer matrix computer programs is demonstrated. The flexibility coefficients are presented in nondimensional tables and plots for ease in use by turbomachinery design engineers and analysts in industry. GRA

N90-20439*# Sikorsky Aircraft, Stratford, CT.
PLAN, FORMULATE, AND DISCUSS A NASTRAN FINITE ELEMENT MODEL OF THE UH-60A HELICOPTER AIRFRAME Final Report
P. DINYOVSZKY and W. J. TWOMEY Feb. 1990 248 p
(Contract NAS1-17499)
(NASA-CR-181975; NAS 1.26:181975) Avail: NTIS HC A11/MF A02 CSCL 20/11

Under a rotorcraft structural dynamics program sponsored by the NASA Langley Research Center, Sikorsky Aircraft, together with the other major helicopter airframe manufacturers, is engaged in a study to improve the use of finite element analysis to predict the dynamic behavior of helicopter airframes. This program, which was designated DAMVIBS (Design Analysis Methods for VIBrationS), includes activities in the areas of: planning, creating, and documenting finite element models of helicopter airframes; the performance of ground vibration tests; and the correlation of test and analysis. The work performed at Sikorsky Aircraft for planning, creating, and documenting a finite element model of the UH-60A BLACK HAWK helicopter airframe is summarized. A complete description of the components of the helicopter which are to be represented in the model is presented and includes: the structural arrangement, the identification of primary and secondary structure, the components of the drive and power trains, and the attachment of large weight items to the structure. Also presented are the techniques which were used to formulate the structural finite element model for static analysis, for forming the mass and vibration models for dynamic analysis, and the procedures which were used to check out and verify the integrity of the model. Initial predictions for the vibration modes for the helicopter are included. Author

N90-20999# Arnold Engineering Development Center, Arnold Air Force Station, TN.
OPTIMIZATION OF AERODYNAMIC DESIGNS USING COMPUTATIONAL FLUID DYNAMICS
D. H. HUDDLESTON and C. W. MASTIN (Mississippi State Univ., Mississippi State.) *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 10 p Mar. 1990 Prepared in cooperation with Sverdrup Technology, Inc., Arnold AFS, TN
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An aerodynamic design optimization technique which couples direct optimization algorithms with the analysis capability provided by appropriate computational fluid dynamics (CFD) programs is presented. This technique is intended to be an aid in designing the aerodynamic shapes and test conditions required for the successful simulation of aircraft engine inlet conditions in a ground test environment. However, the method is applicable to other aerodynamic design problems. The approach minimizes a nonlinear least-squares objective function which may be defined in a region remote to the geometric surface being optimized. In this study finite-difference Euler and Navier-Stokes codes were applied to obtain the objective function evaluations, although the optimization method could be coupled with any CFD analysis technique. Results are presented for a NACA0012 airfoil, convergent/divergent nozzles, and a planar, supersonic forebody simulator design. Author

N90-21229# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.).
ROSAR (HELICOPTER-ROTOR BASED SYNTHETIC APERTURE RADAR)
HELMUT KLAUSING, HORST KALTSCHMIDT, and WOLFGANG KEYDEL (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Wesseling, Germany, F.R.) *In* AGARD, High Resolution Air- and Spaceborne Radar 12 p Oct. 1989
Copyright Avail: NTIS HC A10/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

ROSAR is a synthetic aperture radar concept based on rotating antennas of a helicopter for pilot sight target detection and target localization with high resolution. The ROSAR concept has potential benefits for civil and military helicopterborne imaging applications, if the antennas are mounted at the tips of the rotor blades. The

concept has two main potential benefits, the imaging field of view is 360 deg and there is no need for a forward velocity of the carrier platform. As opposed to SAR systems based on linear movement of the antenna, ROSAR imaging is based on synthetic aperture of a circular shape. Thus, the image formation process requires a polar format processing architecture. The ROSAR principle is also applicable for other radar mapping systems with rotating antennas, not only for helicopters. Author

N90-21243*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AIRBORNE DOPPLER RADAR FLIGHT EXPERIMENTS FOR THE DETECTION OF MICROBURSTS
HANS-J. C. BLUME, C. D. LYTLE, W. R. JONES, E. M. BRACALENTE, and C. L. BRITT (Research Triangle Inst., Research Triangle Park, NC.) *In* AGARD, High Resolution Air- and Spaceborne Radar 14 p Oct. 1989
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In the interest of aviation safety, NASA and the FAA are jointly conducting research to determine the applicability of airborne, coherent Doppler radar techniques to detect early microburst in wind shear conditions during aircraft takeoff and landing. Researchers have developed a computer model of the radar which predicts its response when viewing a simulated microburst against the simulated clutter background of an airport, the so-called radar microburst ground clutter model. Studies employing this model revealed that Doppler radar can accurately detect microburst ahead of the aircraft in time for pilot evasive response, but flight experiments will be required for complete performance evaluation of the system. An experimental X band radar is being developed for future flight experiments to verify the simulation modeling results. A description of the experimental radar, recording equipment, and its installation on the NASA 515 aircraft is presented. The flight experiments to be conducted are also described. Author

N90-21247# Scientech, Inc., Idaho Falls, ID.
BOEING 727-100 TEST PROJECT (HIGH ENERGY RADIATED FIELD TESTS) Final Report, Dec. 1985 - Jan. 1986
T. CROWTHER, L. J. YBARRONDO, N. SKOUSEN, and M. HINTZE Jul. 1989 148 p
(Contract DTFA03-88-A-00027)
(DOT/FAA/CT-88/33) Avail: NTIS HC A07/MF A01

Discussed here is a radio frequency (RF) coupling test on a BOEING 727-100 commercial aircraft. The objective of the test was to measure the coupling, or penetration, of RF signals in a BOEING 727-100 in the frequency range of 1.0 MHz to 6.0 GHz. The RF field levels generated inside the airplane during flight are probably not a health hazard with respect to passengers and crew because exposure time to high intensity RF fields is of short duration. However, this project has demonstrated that RF energy can couple into aircraft compartments and onto electrical wiring. The extent to which existing RF sources can impose unwanted electrical signals or voltages on critical aircraft components during flyby are shown. Author

N90-21248# Federal Aviation Administration, Atlantic City, NJ.
FEASIBILITY OF USING FREQUENCY OFFSET ON VERY HIGH FREQUENCY AIR/GROUND VOICE CHANNELS
MARTIN BADINELLI, ARTHUR CUSHMAN, and PHILIP RANDAZZO Mar. 1990 48 p
(DOT/FAA/CT-TN89/71) Avail: NTIS HC A03/MF A01

In some large Federal Aviation Administration (FAA) air traffic control sectors, the controller manually switches between multiple ground transmitters to communicate with aircraft at opposite ends of the sector. This puts an additional burden on the controller. Aeronautical Radio, Inc. (ARINC) uses a frequency offset system which produces five frequencies from one channel assignment. ARINC provides this service to commercial air carriers who use receivers designed to ARINC specifications. These receivers are capable of eliminating the audio heterodyne generated by the offsetting process. The commercial air carriers use this system for airline business. The testing performed at the FAA Technical Center to evaluate this system as a means of controlling the air traffic in large sectors is described. The tests indicate that a frequency offset system cannot be used with general aviation aircraft receivers because many cannot filter out the audio heterodyne. Use of frequency offset may be possible in high altitude sectors where commercial aviation receivers, which meet ARINC specifications, are used if some additional concerns are resolved. Author

N90-21249# Computer Resource Management, Inc., Vienna, VA.
NATIONAL AIRSPACE SYSTEM AIR-GROUND COMMUNICATIONS OPERATIONAL CONCEPT
WILLIAM TRENT, RODNEY KUHN, and THOMAS PICKERELL Feb. 1990 46 p
(Contract DTFA01-88-Y-01073)
(DOT/FAA/DS-90/2; NAS-SR-1361) Avail: NTIS HC A03/MF A01

A requirement for the National Airspace System (NAS) is to provide for air-ground communications, as identified in the NAS System Requirement Specification, NAS-SR-1000. A concept of operations for air-ground communications is presented. Air-ground communications capabilities are described and the relationships are shown between subsystems, facilities, information, and operators/users. A common perspective is provided for personnel involved in air-ground communication activities. Assistance is provided for determining whether air-ground communications meet formal requirements and also for coordinating the organizations involved. Author

N90-21283*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CIVIL AIR TRANSPORT: A FRESH LOOK AT POWER-BY-WIRE AND FLY-BY-LIGHT
GALE R. SUNDBERG May 1990 6 p Presented at the National Aerospace and Electronics Conference, Dayton, OH, 21-25 May 1990; sponsored by IEEE
(NASA-TM-102574; E-5402; NAS 1.15:102574) Avail: NTIS HC A02/MF A01 CSCL 09/3

Power-by-wire (PBW) is a key element under subsonic transport flight systems technology with potential savings of over 10 percent in gross take-off-weight and in fuel consumption compared to today's transport aircraft. The PBW technology substitutes electrical actuation in place of centralized hydraulics, uses internal starter-motor/generators and eliminates the need for variable engine bleed air to supply cabin comfort. The application of advanced fiber optics to the electrical power system controls, to built-in-test (BITE) equipment, and to fly-by-light (FBL) flight controls provides additional benefits in lightning and high energy radio frequency (HERF) immunity over existing mechanical or even fly-by-wire controls. The program plan is reviewed and a snapshot is given of the key technologies and their benefits to all future aircraft, both civil and military. Author

N90-21300*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NAVIER-STOKES ANALYSIS OF TURBINE BLADE HEAT TRANSFER
R. J. BOYLE 1990 21 p Prepared for presentation at the 35th International Gas Turbine and Aeroengine Congress and Exposition, Brussels, Belgium, 11-14 Jun. 1990; sponsored in part by ASME
(NASA-TM-102496; E-5219; NAS 1.15:102496) Avail: NTIS HC A03/MF A01 CSCL 20/4

Comparisons with experimental heat transfer and surface pressures were made for seven turbine vane and blade geometries using a quasi-three-dimensional thin-layer Navier-Stokes analysis. Comparisons are made for cases with both separated and unseparated flow over a range of Reynolds numbers and freestream turbulence intensities. The analysis used a modified Baldwin-Lomax turbulent eddy viscosity mode. Modifications were made to account for the effects of: (1) freestream turbulence on both transition

and leading edge heat transfer; (2) strong favorable pressure gradients on relaminarization; and (3) variable turbulent Prandtl number heat transfer. In addition, the effect of heat transfer on the near wall model of Deissler is compared with the Van Driest model. Author

N90-21361*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ATTACHMENT OF LEAD WIRES TO THIN FILM THERMOCOUPLES MOUNTED ON HIGH TEMPERATURE MATERIALS USING THE PARALLEL GAP WELDING PROCESS
RAYMOND HOLANDA, WALTER S. KIM, ERIC PENCIL, MARY GROTH (Cincinnati Univ., OH.), and GERALD A. DANZEY 1990 19 p Presented at the 177th Meeting of the Electrochemical Society, Montreal, Quebec, 6-11 May 1990
(NASA-TM-102442; E-5218; NAS 1.15:102442) Avail: NTIS HC A03/MF A01 CSCL 14/2

Parallel gap resistance welding was used to attach lead wires to sputtered thin film sensors. Ranges of optimum welding parameters to produce an acceptable weld were determined. The thin film sensors were Pt13Rh/Pt thermocouples; they were mounted on substrates of MCrAlY-coated superalloys, aluminum oxide, silicon carbide and silicon nitride. The entire sensor system is designed to be used on aircraft engine parts. These sensor systems, including the thin-film-to-lead-wire connectors, were tested to 1000 C. Author

N90-21394*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TRANSMISSION RESEARCH ACTIVITIES AT NASA LEWIS RESEARCH CENTER
D. G. LEWICKI 1990 31 p Presented at the Helicopter Transmission Design and Maintenance Workshop, Quebec City, Quebec, 21-25 May 1990; sponsored by Canadian Department of National Defense Prepared in cooperation with Army Aviation Systems Command, Cleveland, OH
(Contract DA PROJ. 1L1-2211-A-47-A)
(NASA-TM-103132; E-5469; NAS 1.15:103132; AVSCOM-TM-90-C-006) Avail: NTIS HC A03/MF A01 CSCL 13/9

A joint research program, to advance the technology of rotorcraft transmissions, consists of analytical and experimental efforts to achieve the overall goals of reducing transmission weight and noise, while increasing life and reliability. Recent activities in the areas of transmission and related component research are highlighted. Current areas include specific technologies in support of military rotary wing aviation, gearing technology, transmission noise reduction studies, a recent interest in gearbox diagnostics, and advanced transmission system studies. Results of recent activities are presented along with near term research plans. Author

N90-21395*# Mechanical Technology, Inc., Latham, NY.
INTERNAL ROTOR FRICTION INSTABILITY Final Report, Nov. 1983 - Oct. 1987
J. WALTON, A. ARTILES, J. LUND, J. DILL, and E. ZORZI Feb. 1990 169 p
(Contract NAS8-35601)
(NASA-CR-183942; NAS 1.26:183942; MTI-88TR39) Avail: NTIS HC A08/MF A01 CSCL 13/9

The analytical developments and experimental investigations performed in assessing the effect of internal friction on rotor systems dynamic performance are documented. Analytical component models for axial splines, Curvic splines, and interference fit joints commonly found in modern high speed turbomachinery were developed. Rotor systems operating above a bending critical speed were shown to exhibit unstable subsynchronous vibrations at the first natural frequency. The effect of speed, bearing stiffness, joint stiffness, external damping, torque, and coefficient of friction, was evaluated. Testing included material coefficient of friction evaluations, component joint quantity and form of damping determinations, and rotordynamic stability assessments. Under conditions similar to those in the SSME turbopumps, material interfaces experienced a coefficient of friction of approx. 0.2 for lubricated and 0.8 for unlubricated conditions. The damping observed in the component joints displayed nearly linear behavior with increasing amplitude. Thus, the measured damping, as a function of amplitude, is not represented by either linear or Coulomb friction damper models. Rotordynamic testing of an axial spline joint under 5000 in.-lb of static torque, demonstrated the presence of an extremely severe instability when the rotor was operated above its first flexible natural frequency. The presence of this instability was predicted by nonlinear rotordynamic time-transient analysis using the nonlinear component model developed under this program. Corresponding rotordynamic testing of a shaft with an interference fit joint demonstrated the presence of subsynchronous vibrations at the first natural frequency. While subsynchronous vibrations were observed, they were bounded and significantly lower in amplitude than the synchronous vibrations. Author

N90-21399*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AEROPROPULSION FACILITIES CONFIGURATION CONTROL: PROCEDURES MANUAL
JAMES J. LAVELLE Mar. 1990 24 p
(NASA-TM-102541; E-5351; NAS 1.15:102541) Avail: NTIS HC A03/MF A01 CSCL 14/4

Lewis Research Center senior management directed that the aeropropulsion facilities be put under configuration control. A Configuration Management (CM) program was established by the Facilities Management Branch of the Aeropropulsion Facilities and Experiments Division. Under the CM program, a support service contractor was engaged to staff and implement the program. The Aeronautics Directorate has over 30 facilities at Lewis of various sizes and complexities. Under the program, a Facility Baseline List (FBL) was established for each facility, listing which systems and their documents were to be placed under configuration control. A Change Control System (CCS) was established requiring that any proposed changes to FBL systems or their documents were to be processed as per the CCS. Limited access control of the FBL master drawings was implemented and an audit system established to ensure all facility changes are properly processed. This procedures manual sets forth the policy and responsibilities to ensure all key documents constituting a facilities configuration are kept current, modified as needed, and verified to reflect any proposed change. This is the essence of the CM program. Author

N90-21422*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NASA AIRFRAME STRUCTURAL INTEGRITY PROGRAM
CHARLES E. HARRIS Apr. 1990 20 p
(NASA-TM-102637; NAS 1.15:102637) Avail: NTIS HC A03/MF A01 CSCL 20/11

NASA initiated a research program with the long-term objective of supporting the aerospace industry in addressing issues related to the aging of the commercial transport fleet. The program combines advanced fatigue crack growth prediction methodology with innovative nondestructive examination technology with the focus on multi-stage damage (MSD) at rivited connections. A fracture mechanics evaluation of the concept of pressure proof testing the fuselage to screen for MSD was completed. A successful laboratory demonstration of the ability of the thermal flux method to detect disbonds at rivited lap splice joints was conducted. All long-term program elements were initiated, and the plans for the methodology verification program are being coordinated with the airframe manufacturers. Author

N90-21424*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN EVALUATION OF THE PRESSURE PROOF TEST CONCEPT FOR THIN SHEET 2024-T3
D. S. DAWICKE (Analytical Services and Materials, Inc., Hampton, VA.), C. C. POE, JR., JAMES C. NEWMAN, JR., and CHARLES

E. HARRIS Apr. 1990 32 p
(NASA-TM-101675; NAS 1.15:101675) Avail: NTIS HC A03/MF A01 CSCL 20/11

The concept of pressure proof testing of fuselage structures with fatigue cracks to insure structural integrity was evaluated from a fracture mechanics viewpoint. A generic analytical and experimental investigation was conducted on uniaxially loaded flat panels with crack configurations and stress levels typical of longitudinal lap splice joints in commercial transport aircraft fuselages. The results revealed that the remaining fatigue life after a proof test was longer than that without the proof test because of crack growth retardation due to increased crack closure. However, based on a crack length that is slightly less than the critical value at the maximum proof test stress, the minimum assured life or proof test interval must be no more than 550 pressure cycles for a 1.33 proof factor and 1530 pressure cycles for a 1.5 proof factor to prevent in-flight failures. Author

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GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

N90-20500# Federal Aviation Administration, Atlantic City, NJ.
ANALYSIS OF HELIPORT ENVIRONMENTAL DATA: INDIANAPOLIS DOWNTOWN HELIPORT, WALL STREET HELIPORT. VOLUME 3: INDIANAPOLIS DOWNTOWN HELIPORT DATA PLOTS
ROSANNE M. WEISS, JOHN G. MORROW, DONALD GALLAGHER, MARK DIMEO, and SCOTT ERLICHMAN Oct. 1989 436 p Sponsored by FAA, Washington, DC
(AD-A217412; DOT/FAA/CT-TN87/54-VOL-3) Avail: NTIS HC A19/MF A03 CSCL 01/5

During the summer of 1987 heliport environmental data were collected at the Indianapolis Downtown Heliport and at New York's Wall Street Heliport. The purpose of this data collection activity was to obtain measures of rotorwash in the heliport environment due to maneuvering helicopters, and to obtain pilot perceptions and observations concerning maneuvering and parking separation criteria. Ten wind vector transmitters were situated at various locations around the heliport in order to gather information to describe the rotorwash induced wind speed and direction changes. Pilot interviews were also conducted at these heliports. This volume provides the plots generated from the wind sensor data collected at the Indianapolis Downtown Heliport. The results will be considered in future modifications of the Federal Aviation Administration Heliport Design Advisory Circular. GRA

N90-21500# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
METEOROLOGIST WEATHER PROCESSOR (MWP) INTEGRATION TEST PLAN
WILFRED HUBER and BRUCE E. WARE (Data Transformation Corp., Houston, TX.) Mar. 1990 27 p
(DOT/FAA/CT-TN89/62) Avail: NTIS HC A03/MF A01

The Meteorologist Weather Processor (MWP) System is an element of the National Airspace System (NAS) modernization. The initial MWP is a leased interim system which will be replaced after 5 years by an end-state system which will meet all of the requirements of NAS-SS-1000 for the Meteorologist Weather Processor/Central Flow Meteorologist Weather Processor (MWP/CFMWP). The contractor, Harris Corporation, is responsible for all aspects of system support including communications and maintenance. The MWP will be capable of processing weather data from a variety of sources including alphanumeric and graphic products, radar weather data, and satellite imagery. These weather products will be used by the Center Weather Service Unit (CWSU) meteorologists, Traffic Management Unit (TMU) personnel in briefing pilots, and air traffic control (ATC) personnel concerning weather products. Author

N90-21508# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
ANALYSIS OF DISTRIBUTIONS OF VISUAL METEOROLOGICAL CONDITIONS (VMC) HELIPORT DATA Technical Report, Nov. 1988
CHRISTOPHER J. WOLF Mar. 1990 1055 p
(DOT/FAA/CT-TN89/67) Avail: NTIS HC A99/MF E09

The FAA Technical Center's Visual Meteorological Conditions (VMC) project was designed to provide data for the validation of the Heliport Design Advisory Circular (AC 150/5390-2) visual approach/departure surface criteria. Procedures for the analysis of data collected during this project were specified by the Design and Operations Criteria Division, AAS-100. These procedures are based on an assumption of the Gaussian, or Normal, distribution. The results of the VMC Project, based on the assumption of Normal data, are documented in DOT/FAA/CT-TN87/40, Heliport Visual Approach and Departure Airspace Tests. During the data reduction and analysis phase of the VMC project, questions were raised as to validity of the assumption of the Normal distribution for the characterization of VMC data. An effort undertaken to look at the VMC data for the purpose of drawing conclusions about the proper distributional assumption is documented. Several different procedures were used to test the original assumption. Information is provided on the tests used in this effort and on several alternate distributions, i.e., the Beta and Gamma distributions. Author

N90-21509# Federal Aviation Administration, Washington, DC. Flightcrew Systems Research Branch.
WINDSHEAR CASE STUDY: DENVER, COLORADO, JULY 11, 1988 Final Report
HERBERT W. SCHLICKENMAIER Nov. 1989 470 p
(DOT/FAA/DS-89/19) Avail: NTIS HC A20/MF A03

On Monday 11 July 1988 between 2207 and 2213 UTC (16:07 to 16:13 MDT), four successive United flights had inadvertent encounters with microburst windshear conditions while on final approach to Denver Stapleton Airport (DEN), each resulting in a missed approach, subsequent delay, and uneventful arrival. A fifth flight executed a missed approach without encountering the phenomena. All of the flight crews were trained utilizing the resources of the Windshear Training Aid. There was no damage to aircraft and no passenger injuries. At the time the aircraft encountered the microburst, the Terminal Doppler Weather Radar (TDWR) Operations Test and Experiment (OT&E) was in progress and detected divergent flow that intersected the operating zones for the approach runways. The radar used to test the TDWR algorithm was the Massachusetts Institute of Technology Lincoln Laboratory 10 cm Doppler radar. This Windshear Case Study outlines the technical details of the encounter, as well as describes insights gained from this confrontation that should be applied to future investigations of aircraft encountering windshear. Information was summarized from several sources including flight crew comments, air traffic control (ATC) operations and surveillance radar data, flight data recorders, data from the TDWR and the Low-Level Wind Shear Alert System (LLWAS), technical details of the event meteorology, and data from the Terminal Area Simulation System (TASS). Author

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A90-33379#
DESIGN FLUTTER CALCULATIONS ON PC
W. POTKANSKI (PZL, Mielec, Poland) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 301-306.

Vibration modes and critical flutter conditions for aircraft structure are calculated on a PC. A beam stiffness model is considered in which aircraft units are replaced by beams of equivalent stiffness, and control units are replaced by linear springs connecting control surfaces to the main surfaces of the aircraft units. The discrete mass model of aircraft is derived, and calculations for natural vibrations and flutter are presented. Systems design based on the above calculation methods is outlined with emphasis on approximation polynomial selection and geometric, mass, and stiffness data collection; natural stiffness calculations; critical flutter condition calculations; and graphics and report generation. It is noted that it takes approximately 15 to 25 minutes to execute one run of calculations including input data modifications. V.T.

A90-33402#
PRACTICAL TECHNIQUES OF MODELLING AEROELASTIC SYSTEMS FOR ACTIVE CONTROL APPLICATIONS
R. VEPA and A. SAEED (Queen Mary College, London, England) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 529-537. refs

This paper examines various techniques of modeling aeroelastic systems for active control applications, with special attention given to two different modeling approaches: (1) the time invariant differential equation models, based on the approximation of unsteady aerodynamic forces by rational or polynomial transfer functions; and (2) the differential delay modeling method. A design procedure for synthesizing optimal control laws for regulator design using the latter approach is established and is applied to the problem of synthesizing a controller for active flutter suppression. Practical methods for modeling aeroelastic transfer functions by combining the advantages of both approaches are discussed. I.S.

A90-33921#
AN EXPERT SYSTEM FOR REAL-TIME AIRCRAFT MONITORING
JOEY B. FLANDERS, CHARLES H. JONES, and ROBIN M. MADISON (USAF, Edwards AFB, CA) IN: AIAA/SFTE/DGLR/SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 345-353. refs
(AIAA PAPER 90-1311)

State-of-the-art off-the-shelf hardware and software are noted to furnish a cost-effective basis for the development of real-time expert systems engaged in aircraft monitoring. The implementation of such systems requires, however, the development of graphics displays which conceptually organize the data and can provide more complete verbal descriptions of displayed data. Once this man-machine interface has been thus enhanced, rule-based inferencing can be added to drive the displays. Attention is presently given to a propulsion expert system encompassing general aircraft information, strip charts, expert system message displays, and engine diagrams. O.C.

A90-34103
A STUDY OF SYMBOLIC PROCESSING AND COMPUTATIONAL ASPECTS IN HELICOPTER DYNAMICS
S. RAVICHANDRAN, G. GAONKAR (Florida Atlantic University, Boca Raton), J. NAGABHUSHANAM (Indian Institute of Science, Bangalore, India), and T. S. R. REDDY (Toledo, University, OH) Journal of Sound and Vibration (ISSN 0022-460X), vol. 137, March 22, 1990, p. 495-507. Research supported by the U.S. Army. refs
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The symbolic processors for the generation of the equations of motion for helicopter dynamics are studied, focusing on a comparison between the general-purpose symbolic processor, REDUCE, and the special-purpose symbolic processor, Dynamic Equations for Helicopter Interpretive Models (DEHIM). REDUCE and DEHIM are applied to the same set of problems, ranging from a linear model with one DOF to a mildly nonlinear multibladed rotor model with several DOFs. Consideration is given to the computational issues related to the application of Floquet theory. It is found that DEHIM is more portable and economical than REDUCE, although DEHIM is less user-friendly. R.B.

A90-34150#
FLIGHT TEST DATA PROCESSING, PLOTTING AND ANALYSIS AT YOUR FINGER TIPS - A FLEXIBLE, AUTOMATED, INTEGRATED APPROACH
W. G. SCHWEIKHARD, S. J. PLATZ, D. E. HALVERSTADT, DARIN LANDIS, ELIAS BOUNAJEM (Kohlman Systems Research, Lawrence, KS) et al. AIAA, SFTE, DGLR, and SETP, Biannual Flight Test Conference, 5th, Ontario, CA, May 22-24, 1990. 14 p.
(AIAA PAPER 90-1322) Copyright

A flight test application software package (FTASP) designed to assist in the testing, evaluation, and development of military and civil aircraft is described. The software architecture covers the flight test objectives of aircraft performance, as well as stability and control. The FTASP configuration is outlined, including setup, flight test data base generation, performance standardization, specification compliance, parameter identification, and utility modules. It is shown that the package facilitates and expedites the process for producing the final results by allowing changes to be made to the input and setup data and data processing routines without compromising the integrity of the measured input data or the core analysis software. It is also noted that this concept can be utilized to accommodate the flight test disciplines of propulsion, loads, structural dynamics, and systems test. V.T.

A90-34185
A DISTRIBUTED ARTIFICIAL INTELLIGENCE APPROACH TO OBJECT IDENTIFICATION AND CLASSIFICATION
DIGVIJAY I. SIKKA, PRAMOD K. VARSHNEY (Syracuse University, NY), and VINCENT C. VANNICOLA (USAF, Rome Air Development Center, Griffiss AFB, NY) IN: Sensor fusion II; Proceedings of the Meeting, Orlando, FL, Mar. 28, 29, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 73-84. refs
Copyright

This paper presents an application of Distributed Artificial Intelligence (DAI) tools to the data fusion and classification problem. A blackboard is used for information managemeant and hypotheses formulation. The blackboard is used by the knowledge sources (KSs) for sharing information and posting their hypotheses on, just as experts sitting around a round table would do. The present simulation performs classification of an aircraft, after identifying it by its features, into disjoint sets (object classes) comprising the five commercial aircraft: Boeing 747, Boeing 707, DC10, Concorde, and Boeing 727. A situation data base is characterized by experimental data available from the three levels of expert reasoning. To validate the architecture presented, two KSs are employed to model the sensors, aspect angle polarization feature, and the ellipticity data. Author

A90-34378
BENCHMARK CALCULATIONS WITH AN UNSTRUCTURED GRID FLOW SOLVER ON A SIMD COMPUTER
JEFF S. CLARY, GEORGE A. HOWELL, and STEVE L. KARMAN, JR. (General Dynamics Corp., Fort Worth, TX) IN: Supercomputing '89; Proceedings of the Second Conference, Reno, NV, Nov. 13-17, 1989. Washington, DC/New York, IEEE Computer Society/ACM Press, 1989, p. 32-41. refs
Copyright

An unstructured grid flow solver was implemented on a massively parallel computer, and benchmark computations were performed. The solver was a two-dimensional computational fluid dynamics (CFD) code that performs first-order, steady-state solutions of the Euler equations. The parallel computer used was the Connection Machine. The CFD code was programed in Asterisk-Lisp, the accuracy of the code was verified, and numerous optimizations were implemented. Several benchmark runs were then made to assess and understand the impact of the code modifications and to obtain meaningful performance comparisons with other advanced computers. I.E.

A90-34382
CAPABILITY OF CURRENT SUPERCOMPUTERS FOR THE COMPUTATIONAL FLUID DYNAMICS
KOZO FUJII and YOSHIAKI TAMURA (Institute of Space and Astronautical Science, Sagamihara, Japan) IN: Supercomputing '89; Proceedings of the Second Conference, Reno, NV, Nov. 13-17, 1989. Washington, DC/New York, IEEE Computer Society/ACM Press, 1989, p. 71-80. refs
Copyright

The computer code named LANS3D, one of the representative Navier-Stokes codes in Japan, is taken as an example, and the capability of the current computational fluid dynamics (CFD) technology is discussed. This code was developed for the numerical simulation of high-Reynolds-number compressible flows. The algorithm used in this code and how it has been improved so far explain two important aspects of the CFD codes: efficiency and accuracy. Some of the application examples show the capability of the code for solving engineering problems as well as physical problems. The benchmark test of the newest version of the code on supercomputers indicates that recent supercomputer improvement enables the code to be a strong engineering tool for design purposes. At the same time, it is concluded that still more compiler improvement may lead to the best use of the supercomputers for computational fluid dynamics. I.E.

A90-34436* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EFFECTIVE USE OF CRAY SUPERCOMPUTERS
WILLIAM T. C. KRAMER and JAMES M. CRAW (NASA, Ames Research Center, Moffett Field, CA) IN: Supercomputing '89; Proceedings of the Second Conference, Reno, NV, Nov. 13-17, 1989. Washington, DC/New York, IEEE Computer Society/ACM Press, 1989, p. 721-731. refs
Copyright

A discussion is presented of several areas where system management and user support can have a large impact in the overall efficiency of the Cray supercomputer. After an introduction to the environment at the Numerical Aerodynamic Simulation Project is given as background, the areas which are common to UNIX system management are examined. Then, the specific areas of the UNICOS supercomputer which must be used to operate the system efficiently are discussed. Methods of supporting individual users in order to increase their effectiveness and the efficiency of their programs are also discussed. I.E.

N90-20656*# Dual and Associates, Houston, TX.
THE REAL TIME DISPLAY BUILDER (RTDB)
ERICK D. KINDRED and SAMUEL A. BAILEY, JR. *In* NASA, Lyndon B. Johnson Space Center, Graphics Technology in Space Applications (GTSA 1989) p 33-38 Aug. 1989
Avail: NTIS HC A11/MF A02 CSCL 09/2

The Real Time Display Builder (RTDB) is a prototype interactive graphics tool that builds logic-driven displays. These displays reflect current system status, implement fault detection algorithms in real time, and incorporate the operational knowledge of experienced flight controllers. RTDB utilizes an object-oriented approach that integrates the display symbols with the underlying operational logic. This approach allows the user to specify the screen layout and the driving logic as the display is being built. RTDB is being developed under UNIX in C utilizing the MASSCOMP graphics environment with appropriate functional separation to ease portability to other graphics environments. RTDB grew from the need to develop customized real-time data-driven Space Shuttle systems displays. One display, using initial functionality of the tool, was operational during the orbit phase of STS-26 Discovery. RTDB is being used to produce subsequent displays for the Real Time Data System project currently under development within the Mission Operations Directorate at NASA/JSC. The features of the tool, its current state of development, and its applications are discussed.
Author

N90-20998# Princeton Univ., NJ.
AERODYNAMIC DESIGN VIA CONTROL THEORY
ANTONY JAMESON *In* AGARD, Computational Methods for Aerodynamic Design (Inverse) and Optimization 32 p Mar. 1990
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The purpose is to demonstrate by representative examples that control theory can be used to formulate computationally feasible procedures for aerodynamic design. The cost of each iteration is of the same order as two flow solutions, since the adjoint equation is of comparable complexity to the flow equation, and the remaining auxiliary equations could be solved quite inexpensively. Provided, therefore, that one can afford the cost of a moderate number of flow solutions, procedures of this type can be used to derive improved designs. The approach is quite general, not limited to particular choices of the coordinate transformation or cost function, which might in fact contain measures of other criteria of performance such as lift and drag. For the sake of simplicity certain complicating factors, such as the need to include a special term in the mapping function to generate a corner at the trailing edge, have been suppressed from the present analysis. Also it remains to explore the numerical implementation of the design procedures proposed. Author

N90-21539*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
EVOLUTION OF ADA TECHNOLOGY IN THE FLIGHT DYNAMICS AREA: IMPLEMENTATION/TESTING PHASE ANALYSIS
KELVIN L. QUIMBY, LINDA ESKER, JOHN MILLER, LAURIE SMITH (Computer Sciences Corp., Greenbelt, MD.), MIKE STARK, and FRANK MCGARRY Nov. 1989 100 p
(NASA-TM-103310; NAS 1.15:103310; SEL-89-004) Avail: NTIS HC A05/MF A01 CSCL 09/2

An analysis is presented of the software engineering issues related to the use of Ada for the implementation and system testing phases of four Ada projects developed in the flight dynamics area. These projects reflect an evolving understanding of more effective use of Ada features. In addition, the testing methodology used on these projects has changed substantially from that used on previous FORTRAN projects. Author

N90-21541*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
SYSTEM TESTING OF A PRODUCTION ADA (TRADEMARK) PROJECT: THE GRODY STUDY
JEFFREY SEIGLE, LINDA ESKER, and YING-LIANG SHI (Computer Sciences Corp., Greenbelt, MD.) 1990 40 p
(NASA-TM-103308; NAS 1.15:103308; SEL-88-001) Avail: NTIS HC A03/MF A01 CSCL 09/2

The use of the Ada language and design methodologies that utilize its features has a strong impact on all phases of the software development project lifecycle. At the National Aeronautics and

Space Administration/Goddard Space Flight Center (NASA/GSFC), the Software Engineering Laboratory (SEL) conducted an experiment in parallel development of two flight dynamics systems in FORTRAN and Ada. The teams found some qualitative differences between the system test phases of the two projects. Although planning for system testing and conducting of tests were not generally affected by the use of Ada, the solving of problems found in system testing was generally facilitated by Ada constructs and design methodology. Most problems found in system testing were not due to difficulty with the language or methodology but to lack of experience with the application. Author

N90-21542*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
EVOLUTION OF ADA TECHNOLOGY IN THE FLIGHT DYNAMICS AREA: DESIGN PHASE ANALYSIS
KELVIN L. QUIMBY and LINDA ESKER (Computer Sciences Corp., Greenbelt, MD.) Dec. 1988 66 p
(NASA-TM-103307; NAS 1.15:103307; SEL-88-003) Avail: NTIS HC A04/MF A01 CSCL 09/2

The software engineering issues related to the use of the Ada programming language during the design phase of an Ada project are analyzed. Discussion shows how an evolving understanding of these issues is reflected in the design processes of three generations of Ada projects. Author

N90-21543*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
SOFTWARE MANAGEMENT ENVIRONMENT (SME) CONCEPTS AND ARCHITECTURE
WILLIAM DECKER and JON VALETT Aug. 1989 67 p
(NASA-TM-103306; NAS 1.15:103306; SEL-89-003) Avail: NTIS HC A04/MF A01 CSCL 09/2

The concepts and architecture of the Software Management Environment (SME) currently under development for the Systems Development Branch of the Flight Dynamics Division of the Goddard Space Flight Center (GSFC) are presented. The SME will provide an integrated set of management tools that can assist software development managers in the management and planning of flight dynamics software development projects. Author

N90-21544*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
IMPLEMENTATION OF A PRODUCTION ADA PROJECT: THE GRODY STUDY
SARA GODFREY and CAROLYN ELIZABETH BROPHY (Maryland Univ., College Park.) Sep. 1989 149 p
(NASA-TM-103305; SEL-89-002; NAS 1.15:103305) Avail: NTIS HC A07/MF A01 CSCL 09/2

The use of the Ada language and design methodologies that encourage full use of its capabilities have a strong impact on all phases of the software development project life cycle. At the National Aeronautics and Space Administration/Goddard Space Flight Center (NASA/GSFC), the Software Engineering Laboratory (SEL) conducted an experiment in parallel development of two flight dynamics systems in FORTRAN and Ada. The differences observed during the implementation, unit testing, and integration phases of the two projects are described and the lessons learned during the implementation phase of the Ada development are outlined. Included are recommendations for future Ada development projects. Author

N90-21571*# Mississippi State Univ., Mississippi State. Dept. of Aerospace Engineering.
ADAPTIVE GRID EMBEDDING FOR THE TWO-DIMENSIONAL FLUX-SPLIT EULER EQUATIONS M.S. Thesis
GARY PATRICK WARREN May 1990 77 p
(NASA-CR-186533; NAS 1.26:186533) Avail: NTIS HC A05/MF A01 CSCL 12/1

A numerical algorithm is presented for solving the 2-D flux-split Euler equations using a multigrid method with adaptive grid embedding. The method uses an unstructured data set along with a system of pointers for communication on the irregularly shaped grid topologies. An explicit two-stage time advancement scheme is implemented. A multigrid algorithm is used to provide grid level communication and to accelerate the convergence of the solution to steady state. Results are presented for a subcritical airfoil and a transonic airfoil with 3 levels of adaptation. Comparisons are made with a structured upwind Euler code which uses the same flux integration techniques of the present algorithm. Good agreement is obtained with converged surface pressure coefficients. The lift coefficients of the adaptive code are within 2 1/2 percent of the structured code for the sub-critical case and within 4 1/2 percent of the structured code for the transonic case using approximately one-third the number of grid points. Author

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PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A90-32505*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NOISE OF A SIMULATED INSTALLED MODEL COUNTERROTATION PROPELLER AT ANGLE-OF-ATTACK AND TAKEOFF/APPROACH CONDITIONS
RICHARD P. WOODWARD (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 24 p. refs
(AIAA PAPER 90-0283) Copyright

Acoustic results for two model counterrotation propellers are presented. The propellers were tested over a range of rotational speeds and propeller axis angles of attack in both the baseline configuration and the installed configuration consisting of a simulated upstream nacelle support pylon and fuselage section. Acoustic data were taken with a polar microphone probe attached to the downstream propeller housing, capable of surveying directivities at several azimuthal locations. The forward and aft rotor power coefficients and fundamental rotor-alone tone levels are found to be directly controlled by propeller axis angle of attack. The second-order rotor-alone tones are strongly influenced by the upstream pylon wake at 80 percent speed; however, rotor-alone mechanisms control the tone level at 90 percent speed, while rotor-rotor interaction tones are essentially unaffected by the presence of the simulated installation. V.T.

A90-33381#
GYROSCOPIC MATRICES IN COMPUTATION OF VIBRATION
KLAUS KOENIG (MBB GmbH, Bremen, Federal Republic of Germany) IN: European Forum on Aeroelasticity and Structural Dynamics, Aachen, Federal Republic of Germany, Apr. 17-19, 1989, Proceedings. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1989, p. 311-316.

Application of small perturbation method to Euler-Newton equation resulting in linearized inertia loads expressed by gyroscopic matrices is assessed. It is noted that if these matrices are added to the classical vibration equation of a structure, the validity of the equation is extended from nonrotating to rotating structures. Construction and handling of the gyroscopic matrices are explained, includes matrices of the unperturbed leading velocity, small perturbations of the leading velocity, small velocity of structural deformation, and small structural deformation itself. Computation of vibrations is presented, and a rotating circular shaft with a disk on its free end is analyzed as an example. V.T.

A90-34090
CORRELATION OF LIFT AND THICKNESS NOISE SOURCES IN VORTEX-AIRFOIL INTERACTION
M. S. HOWE (BBN Laboratories, Inc., Cambridge, MA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 137, Feb. 22, 1990,

p. 1-7. refs
(Contract N00167-87-C-0021)
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A general formula for unsteady surface forces in an incompressible fluid is used to investigate the unsteady lift and drag developed when a two-dimensional airfoil encounters a gust or other region of vortical flow. For a lifting airfoil it is shown that both forces are linearly dependent on the gust velocity, provided that there exists a finite spanwise component of vorticity, and are fully correlated when the flow is turbulent. Application is made to the problem of broadband noise generated by airfoils and rotors in low subsonic motion, and the results are illustrated in terms of a flat plate airfoil at a finite angle of attack. Author

A90-34091
APPLICATION OF ACTIVE NOISE CONTROL TO MODEL PROPELLER NOISE
M. SALIKUDDIN, H. K. TANNA, R. H. BURRIN, and M. M. S. KHAN (Lockheed Aeronautical Systems Co., Marietta, GA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 137, Feb. 22, 1990, p. 9-41. refs
Copyright

Experiments were carried out demonstrating the use of 'active noise control' in reducing cabin noise on the external fuselage surface of turboprop aircraft. The principle of active noise control is to reduce the noise radiated from a primary source by superimposing a signal from a secondary source which is made identical in amplitude but opposite in phase to the primary sound signal. A computer-controlled algorithm was developed to implement this concept in a free field environment, in which the noise from the propeller and the noise measured at several locations on the fuselage were used to create the input for the secondary source. A substantial amount of noise reduction was achieved on the model fuselage surface. I.S.

N90-20794*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NOISE OF A SIMULATED INSTALLED MODEL COUNTERROTATION PROPELLER AT ANGLE-OF-ATTACK AND TAKEOFF/APPROACH CONDITIONS
RICHARD P. WOODWARD 1990 25 p Presented at the 28th Aerospace Sciences Meeting, Reno, NV, 8-11 Jan. 1990; sponsored by AIAA
(NASA-TM-102440; E-5210; NAS 1.15:102440; AIAA-90-0283) Avail: NTIS HC A03/MF A01 CSCL 20/1

Two modern high-speed advanced counterrotation propellers, F7/A7 and F7/A3 were tested in the NASA Lewis Research Center's 9- by 15-Foot Anechoic Wind Tunnel at simulated takeoff/approach conditions of 0.2 Mach. Both rotors were of similar diameter on the F7/A7 propeller, while the aft diameter of the F7/A3 propeller was 85 percent of the forward propeller to reduce tip vortex-aft rotor interaction. The two propellers were designed for similar performance. The propellers were tested in both the baseline configuration and installed configuration consisting of a simulated upstream nacelle support pylon and fuselage section. Acoustic measurements were made with a polar microphone probe which recorded sideline directivities at various azimuthal locations. Aerodynamic measurements were also made to establish propeller operating conditions. The propellers were run at initial blade setting angles adjusted to achieve equal forward/aft torque ratios at angle of attack with the pylon and fuselage simulation in place. Data are presented for propeller operation at 80 and 90 percent of design speed (the forward rotor design tip speed was 238 m/sec (780 ft/sec). Both propellers were tested at the maximum rotor-rotor spacing of 14.99 cm (5.90 in.) based on the pitch change axis separation. Author

N90-20799# Aerospace Medical Research Labs., Wright-Patterson AFB, OH. Biodynamic Environment Branch.
LATERAL ATTENUATION OF MILITARY AIRCRAFT FLIGHT NOISE Final Report, Apr. 1984 - Sep. 1988
JERRY D. SPEAKMAN Jul. 1989 63 p
(Contract AF PROJ. 7231)
(AD-A218041; AAMRL-TR-89-034) Avail: NTIS HC A04/MF A01 CSCL 20/1

The results are presented of measurements on the noise propagated to the side of military aircraft during a series of controlled level flyovers. Data were acquired on attack/fighter aircraft (A-10A, F4D, F-5E, F-15, F-16, and F-18); bomber aircraft (B-52G and FB-111); cargo/tanker aircraft (C-18, C-141, KC-10A, KC-135A, and KC-135R); and special purpose aircraft (C-21 and E-3A). In addition to the normal attenuation provided by wave divergence (spherical spreading) and atmospheric absorption, noise propagated laterally to the ground from aircraft during flight is further reduced by the combination of several other frequency dependent phenomena such as ground, meteorological, forward flight, and engine/airplane installation effects. Airbase/airport noise models typically define this extra lateral attenuation for single event measures such as the Sound Exposure Level as a function of the elevation angle as viewed from a given location on the ground. Based on the results of these data, a new algorithm was developed and incorporated in the Air Force NOISEMAP model. GRA

N90-20800# Aerospace Medical Research Labs., Wright-Patterson AFB, OH. Biodynamic Environment Branch.
AIR FORCE BOOM EVENT ANALYZER RECORDER (BEAR): SYSSTEM DESCRIPTION Final Report, Oct. 1985 - Aug. 1989
ROBERT A. LEE, MONTY CRABILL, DOUG MAZUREK, BARBARA PALMER, DALE PRICE, and DOUG MAZUREK Aug. 1989 179 p
(Contract AF PROJ. 7231; AF PROJ. 3037)
(AD-A218048; AAMRL-TR-89-035) Avail: NTIS HC A09/MF A01 CSCL 20/1

Developed, tested, built and used in field studies were several Boom Event Analyzer Recorders (BEARs). These BEAR's operate unattended to capture the wave form of Impulsive Acoustic Events (e.g., Sonic Booms) and their time of occurrance while excluding all other acoustic events. These BEARs are designed to operate unattended for up to 10 days and can store over 50 normal (less than 250 miliseconds in duration) sonic booms. These BEAR systems were used successfully to capture the sonic boom signature from all U.S. supersonic aircraft. A complete system description of the BEAR is presented covering data collection, theory of operation, data storage and retrieval, operation and complete hardware and software description. The comparison test done in cooperation with NASA and field studies using these BEARs are detailed in companion reports. GRA

N90-21602*# General Electric Co., Schenectady, NY.
THE RADIATION OF SOUND FROM A PROPELLER AT ANGLE OF ATTACK Final Report
RAMANI MANI Washington, DC NASA Jan. 1990 53 p
(Contract NAS3-23721)
(NASA-CR-4264; E-5139; NAS 1.26:4264) Avail: NTIS HC A04/MF A01 CSCL 20/1

The mechanism by which the noise generated at the blade passing frequency by a propeller is altered when the propeller axis is at an angle of attack to the freestream is examined. The measured noise field is distinctly non axially symmetric under such conditions with far field sound pressure levels both diminished and increased relative to the axially symmetric values produced with the propeller at zero angle of attack. Attempts have been made to explain this non axially symmetric sound field based on the unsteady (once per rev) loading experienced by the propeller blades when the propeller axis is at non zero angle of attack. A calculation based on this notion appears to greatly underestimate the measured azimuthal asymmetry of noise for high tip speed, highly loaded propellers. A new mechanism is proposed; namely, that at angle of attack, there is a non axially symmetric modulation of the radiative efficiency of the steady loading and thickness noise which is the primary cause of the non axially symmetric sound field at angle of attack for high tip speed, heavily loaded propellers with a large number of blades. A calculation of this effect to first order in the crossflow Mach number (component of

freestream Mach number normal to the propeller axis) is carried out and shows much better agreement with measured noise data on the angle of attack effect. Author

N90-21604*# Pennsylvania State Univ., State College. Noise Control Lab.
FREE-FIELD PROPAGATION OF HIGH INTENSITY NOISE Final Report, 1 Dec. 1979 - 28 Feb. 1983
JOSEPH P. WELZ and OLIVER H. MCDANIEL 1990 78 p
(Contract NAG1-4)
(NASA-CR-186577; NAS 1.26:186577) Avail: NTIS HC A05/MF A01 CSCL 20/1

Observed spectral data from supersonic jet aircraft are known to contain much more high frequency energy than can be explained by linear acoustic propagation theory. It is believed that the high frequency energy is an effect of nonlinear distortion due to the extremely high acoustic levels generated by the jet engines. The objective, to measure acoustic waveform distortion for spherically diverging high intensity noise, was reached by using an electropneumatic acoustic source capable of generating sound pressure levels in the range of 140 to 160 decibels (re 20 micro Pa). The noise spectrum was shaped to represent the spectra generated by jet engines. Two microphones were used to capture the acoustic pressure waveform at different points along the propagation path in order to provide a direct measure of the waveform distortion as well as spectral distortion. A secondary objective was to determine that the observed distortion is an acoustic effect. To do this an existing computer prediction code that deals with nonlinear acoustic propagation was used on data representative of the measured data. The results clearly demonstrate that high intensity jet noise does shift the energy in the spectrum to the higher frequencies along the propagation path. In addition, the data from the computer model are in good agreement with the measurements, thus demonstrating that the waveform distortion can be accounted for with nonlinear acoustic theory. Author

N90-21605*# Lockheed Engineering and Sciences Co., Hampton, VA.
SONIC BOOM SIGNATURE DATA FROM CRUCIFORM MICROPHONE ARRAY EXPERIMENTS DURING THE 1966-1967 EAFB NATIONAL SONIC BOOM EVALUATION PROGRAM
H. H. HUBBARD and D. J. MAGLIERI (Eagle Engineering, Inc., Hampton, VA.) May 1990 54 p
(Contract NAS1-19000; NAS9-17900)
(NASA-CR-182027; NAS 1.26:182027) Avail: NTIS HC A04/MF A01 CSCL 20/1

Tables are provided of measured sonic boom signature data derived from supersonic flyover tests of the XB-70, B-58 and F-104 aircraft for ranges of altitude and Mach number. These tables represent a convenient hard copy version of available electronic files and complement preliminary information included in a reference National Sonic Boom Evaluation Office document. Author

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A90-31686#
TEAMWORK FOR EXCELLENCE
SHABBIR SHAD and JANE HAGA (LTV Aircraft Products Group, Dallas, TX) IN: AIAA/ADPA/NSIA National Total Quality Management Symposium, 1st, Denver, CO, Nov. 1-3, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 62-72. refs
(AIAA PAPER 89-3195) Copyright

Implementation of a long-range plan is outlined that includes the assumptions, principles, goals, and strategy to integrate a total quality philosophy into strategic planning for continuous improvement. Focus is then placed on a measurement and reporting system that indicates whether the continuous improvement efforts are successful. Finally, a summary of the lessons learned in introducing total quality management in an aerospace and defense company is given. R.E.P.

A90-31696#
WHAT CAN WE DO AFTER WE'VE DONE IT ALL?
R. W. NEWHOUSE (General Dynamics Corp., Fort Worth, TX) IN: AIAA/ADPA/NSIA National Total Quality Management Symposium, 1st, Denver, CO, Nov. 1-3, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 123-125.
(AIAA PAPER 89-3209) Copyright

Total quality management (TQM) at General Dynamics is defined as a leadership philosophy that creates a working environment which promotes teamwork, trust, and the quest for continuous improvement. To demonstrate that management was serious about TQM it was necessary for the total organization to be involved. For total involvement, each level had to realize what it needed to know and do, and the process would only be sustained if a supporting structure was put in place. With that realization, an approach to assuring long-term continual success was initiated. Long-range benefits are anticipated through this approach of establishing strategic and operational goals that include: improved internal and external customer relations, improved processes that can support people, and improved attitude and output of employees at all levels. R.E.P.

A90-31698#
TOTAL QUALITY MANAGEMENT AND THE TRANSITIONING COMPANY - THE PERFECT FIT
MICHAEL J. PISCATELLA (Textron Lycoming, Stratford, CT) IN: AIAA/ADPA/NSIA National Total Quality Management Symposium, 1st, Denver, CO, Nov. 1-3, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 136-141.
(AIAA PAPER 89-3211) Copyright

The path that Textron Lycoming is taking to achieve a culture of continuous improvement is discussed. A historical perspective illustrates the growing production requirements that resulted in the evolution of the total quality management (TQM) concept. The management team led a strategy to make step-function improvements in process technology and the effectiveness of the workforce in conjunction with assistance provided by the government. This joint effort embodied the basic principles of TQM through the use of quantitative measures and participation of the involved users to continually improve the specific product or service. These changes in technology and human resource skills have allowed significant improvements over the past several years. R.E.P.

A90-31702#
PEACEKEEPER IFSS - A TQM SUCCESS STORY
JOHN PARKER (Martin Marietta Corp., Astronautics Group, Denver, CO) IN: AIAA/ADPA/NSIA National Total Quality Management Symposium, 1st, Denver, CO, Nov. 1-3, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1989, p. 158-166.
(AIAA PAPER 89-3218) Copyright

The planning for the Peacekeeper Instrumentation and Flight Safety System (IFSS) shows how teams were formed at each level of the organization as a vehicle for empowerment, and how this increased employee involvement is the foundation for continuously improved performance. As performance improvement initiatives reach fruition in an empowered environment, they provide

leverage for greater accomplishments. Quality, cost, and schedule performance were improved through the implementation of a total quality management program. R.E.P.

A90-33675#
THE NEXT AIAA ENGINE DESIGN COMPETITION - A COMMERCIAL ENGINE
JAMES L. YOUNGHANS and PAUL D. FEIG (GE Aircraft Engines, Cincinnati, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 25th, Monterey, CA, July 10-12, 1989. 6 p.
(AIAA PAPER 89-2258)

A continuing need to train and educate undergraduate students in the design of airbreathing propulsion systems had led the Airbreathing Propulsion Technical Committee of AIAA to establish a competition emphasizing airbreathing engine design selection and design execution. The 1990 student competition will be based on a 1995 commercial aircraft design scenario. This will consist of designing an 'all new' twin jet commercial aircraft and engine capable of transporting 253 passengers and luggage over a still-air distance of 5900 nautical miles. Since there is no absolute methodology for the design of gas turbines nor for other propulsion systems, the principal purpose is to familiarize the student with the critical steps in the design process. R.E.P.

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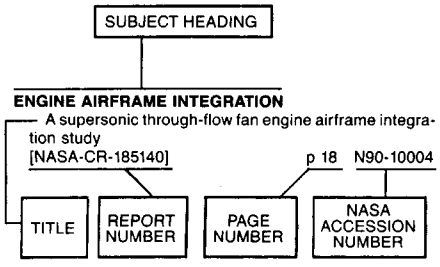

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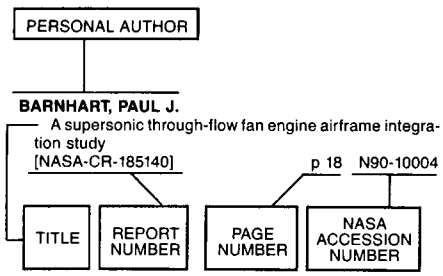

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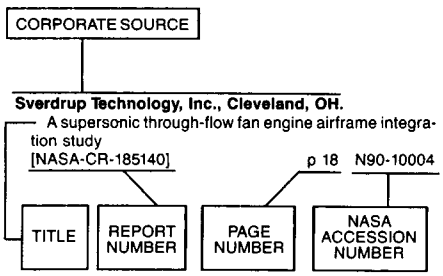

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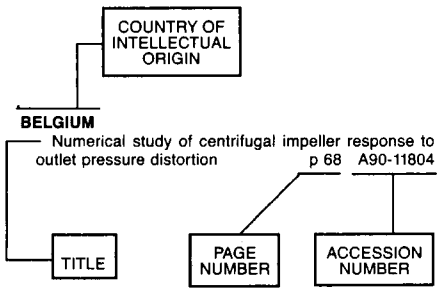

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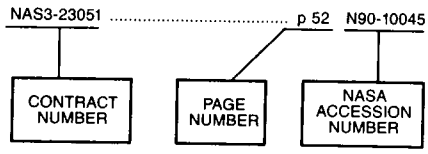

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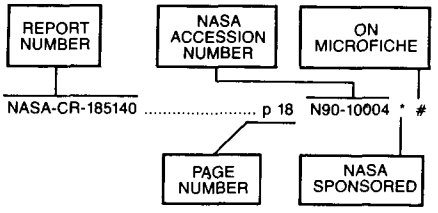

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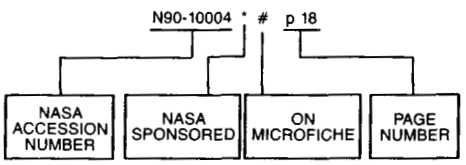

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